

Lessons Learnt from Fires in Buildings

Editor

Javier Hervás



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NEDIES PROJECT

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Javier Hervás



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Abstract

This publication mainly addresses lessons learnt from the management of fires in buildings, both in public and private premises. It reports some relevant or catastrophic fire events occurred in Europe, including such aspects as building structure, occupancy, fire fighting, fire causes and consequences. Major emphasis is placed however on drawing lessons learnt concerning fire prevention and safety measures, emergency plans and other preparedness actions, and intervention of emergency services (mainly fire brigades) for people rescue and fire fighting that can help to prevent and deal with future fires in buildings.

The publication is the result of the contributions from experts from EU Member States and Accession and Candidate Countries that participated in the workshop held at the EC Joint Research Centre (JRC) in Ispra, Italy, on 22-23 September 2003. The workshop was organised within the framework of the JRC's NEDIES Project (Natural and Environmental Disaster Information Exchange System).

Acknowledgements

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Preface

Fires in buildings are a common hazard in built-up areas. Whether they occur in private or public premises, fires cause heavy economic losses to property, contents, personal belongings as well as serious disruption of public services and economic activities. More importantly, many of these fires claim lives.

In order to exchange validated information on and discuss lessons learnt from the management of fires in buildings in different EU Member States and Accession and Candidate Countries that can help policymakers, building designers, emergency services and other stakeholders to prevent and cope with future fires in buildings, a workshop was held in Ispra, Italy, on 22-23 September 2003. The workshop was organised by the European Commission's DG Joint Research Centre (JRC) within the framework of the NEDIES project (Natural Disaster Information Exchange System) of JRC's Institute for the Protection of the Citizen (IPSC). The NEDIES project provides support to the Civil Protection Services of the EU, Candidate and Accession Countries, and other organisations and people involved in the management of natural disasters and technological accidents.

This publication presents the contributions from the experts that participated in the workshop. In addition to describing specific fire events, their cause and consequences, the contributions focus mainly on fire prevention, protection and safety measures (including legislation issues), preparedness plans and actions (including emergency plans), and intervention of emergency services (fire brigades and other personnel). Additional considerations on dissemination of information to the public and socio-economic implications of fires are also included.

The events and lessons learnt reported in this volume refer first to a catastrophic fire in a hotel in Vienna, in Austria. Next, the fire occurred at a senior citizens service house in a small town of Finland is portrayed. This report is followed by the description of the very catastrophic fire in a large department store in the centre of Brussels, Belgium. The fourth event portrayed is a fire in a restaurant complex in a wooden house area in the city of Trondheim, Norway. The next contribution discusses the great fire of Edinburgh, UK, involving five interlinked buildings containing various public premises. The fifth report portrays six major fires in public premises (hospitals, department store, restaurants, show hall and theatre) that occurred in Poland over the last three decades. The next report portrays a fire in an old monastery in Mt. Athos and fires in two large department stores in Athens, in Greece. A fire in a dairy products factory at Nicosia in Cyprus is discussed next. A tactical view of damage and hazard of smoke is provided in the next contribution. In this, two case studies in a basement garage and a penthouse in Germany are also described. After this contribution, the fire in an apartment block in Bucharest, Romania, is discussed. Another fire in an apartment building is portrayed in the next report in Karlstad, Sweden. Next, an overview of the fire control system in Lithuania is given. The final chapter summarises the various lessons learnt contributions including also conclusions drawn from the workshop debate.

This volume is included in the website (<http://nedies.jrc.it>) of the NEDIES project.

Javier Hervás
NEDIES Project

The fire in the Hotel Am Augarten, Vienna, Austria

Frank Peter

Vienna Fire Brigade, Austria

1. Description of the event

The event was chosen for this NEDIES project although it occurred 24 years ago because it was a disastrous fire and a lot of lessons were learnt especially concerning preventive fire protection and their assertion.



Figure 1. View from the Heinestr. Rescue operations and fire fighting still going on

The Hotel Augarten is situated at the corner of Heinestraße and Parzmanitengasse in the 2nd district of Vienna (Fig. 1). It was a block of flats in former days and has been converted into a hotel.

83 guests were sleeping in their rooms in the early morning of 29 September 1979. It is assumed that the fire broke out at about 04.00 hrs. The fire was probably caused by emptying an ashtray into the wastebasket at the reception desk in the entrance hall. The receptionist had left the entrance hall and settled down in his sleeping room in the third floor. The fire smoldered, developed slowly and was unattended for about one hour. The fire produced a big amount of toxic gases. These gases spread through the open stairway and corridors.

At about 05.15 hrs the windows of the entrance hall were bursting as a consequence of the intensity of the fire. The flames and smoke were spotted by passers-by who called the emergency services. The police informed the fire brigade at 05.15 hrs. One minute later the forces of the main fire station "Leopoldstadt" (distant about 2.1 km) consisting of a command vehicle, 3 pumps and one turntable ladder and the engine of the fire station "Brigittenau" (distant about 2.2 km) were set off. Since the command centre received a lot of emergency calls it alarmed a second main fire station "Zentrale" (command vehicle, 3 pumps and one turntable ladder) and a third turntable ladder.

The first engine arrived at the scene at 05.21 hrs. Six fire fighters were confronted by a disastrous situation. The entrance hall was on full fire, the facade was enveloped in smoke, and about 50 screaming people waited at their windows for rescue. The fire respectively blocked the only access or exit. The smoke had filled the staircase and corridors from bottom to the top of the building.

The commander of the first engine decided to split his crew. Using the short ladder they rescued the people of the first floor and at the same time they attacked the fire.

At 05.23 hrs the forces of the fire station "Leopoldstadt" arrived. The fire fighters immediately started rescue operations with ladders (14 m long) and the turntable ladders. As a consequence of the feedback of the commander a third fire station ("Favoriten" - command vehicle, 3 pumps and one turntable ladder), an additional turntable ladder and different special purpose vehicles. Using ladders and 5 turntable ladders the fire fighters rescued 35 guests. The fire fighters even succeeded in rescuing unconscious persons, sometimes not in a gentle but effective way (Fig. 2).

Meanwhile the fire was tackled using several hoses and under control. Troops with breathing apparatus were able to enter the hotel and search the staircase, corridors and rooms for persons. Some persons were found unconscious or dead, some of them still lying on their beds. 25 persons were killed by the fire, actually by the smoke. Some people succeeded in rescuing themselves by climbing out of the window. After one hour the fire was extinguished and after about 3 hours all victims were recovered. About 120 fire fighters and 40 ambulances were on the scene. 13 persons had to be treated in hospital. The fire seriously damaged the building. The complete building was unserviceable because of the soot.



Figure 2. Rescue of an unconscious person using the turntable ladder

Concerning the casualties the fire was the most serious fire in a building in Austria. The fire caused a lot of discussions and led to very strict regulation for hotels

2. Prevention, protection and safety measures

The Hotel Augarten was a bad example for fire safety design. The industrial code did not provide authorization or inspection for hotels (safety of the consumer was not stipulated) until it was revised in 1974 (i.e. 5 years before the fire occurred). The building law did not comprise specific regulations for hotels and because of the nature of the building law it was very difficult to force improvements in fire safety. This major incident prompted new standards, new building and equipment regulations for hotels.

The lesson to be learnt: How not to build a hotel.

The entrance hall had an opulent furnishing with combustible materials. It led directly to the only staircase (Fig. 3). The corridors were not compartmented from the staircase. A lot of the floorings were made from combustible materials.

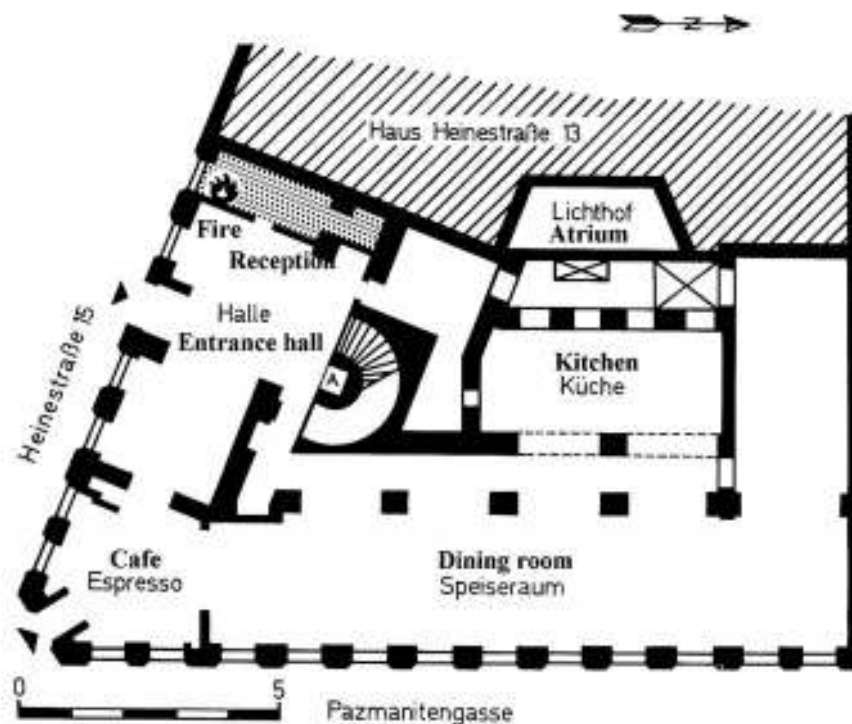


Figure 3. Ground floor of the hotel

The doors to the guest rooms had neither a fire resistance nor a reduced smoke leakage. These circumstances led to an immense production of smoke, which swept through the whole building. Most victims were found in the guest rooms, which had only one door between the corridor and the sleeping room (Fig. 4).

The hotel was not equipped with a fire detection system. The fire was unattended for about one hour! When the fire broke out no staff was present. There were no means of alarming the guests. Since the guests did not receive any alarm a lot of persons were found in their beds. But if they were aware of the fire they had no chance to flee through the smoke filled

corridors. The hotel was situated at the corner of two streets. The fire brigade had the possibility to use ladders and turntable ladders for rescuing the people.

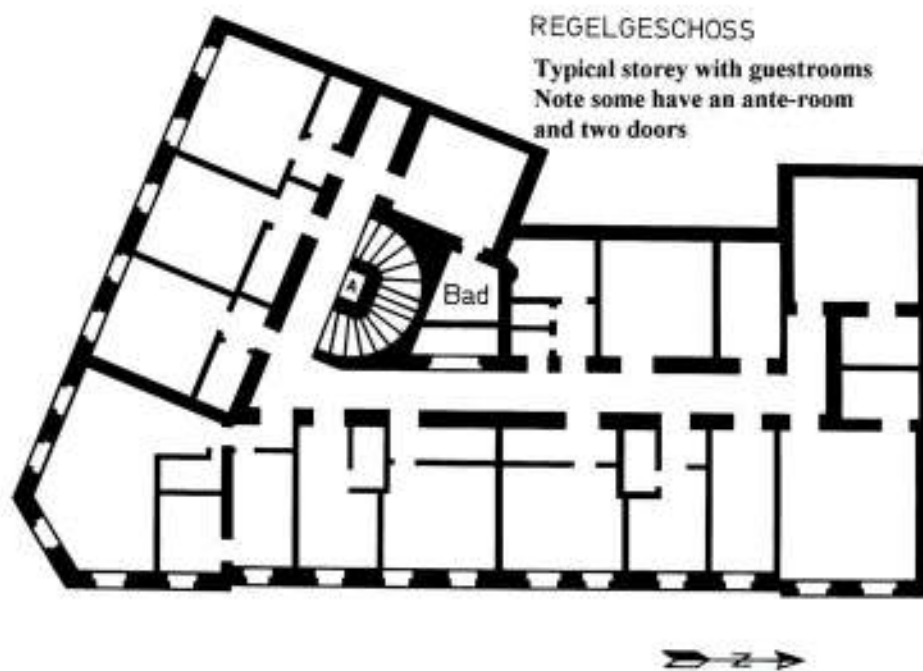


Figure 4. Typical storey with guestrooms

At the beginning of the intervention it was not possible to enter the building. The fire blocked the only access. After the fire had been tackled, the fire fighters using breathing apparatus could search the building and found some victims in the corridors.

The main deficiencies concerning fire safety were:

- Combustible floorings and furnishing.
- No separation between entrance hall, staircase and corridors (see Fig. 5).
- No fire detection system.
- No alarm system.
- No staff present, no staff training.



Figure 5. View from the entrance hall to the staircase

2.1 Lessons learnt

- Regulations (standards, guidelines) must be worked out and executed if there are insufficient provisions by law. New standards for flammability of floorings and furnishings were developed. A new regulation for fire safety in hotels in Vienna and further on a guideline for hotels in Austria were worked out.
- Authorization and regular inspections are necessary. A committee for fire safety improvements in hotels was established. 231 hotels were inspected.
- A second independent mean of escape is imperative.
- Fire Resistance of separating walls /doors (See Fig. 6).
 - Staircase: walls 90 min, doors 30 min.
 - Walls between guestrooms and corridors: 60 min.
 - Walls between guestrooms: 30 min.
- Corridors must be divided into compartments of maximum 20 m.
- The way from the door of the guest room to the next staircase may not exceed 20 m.
- From any point of the building you must reach the next staircase or the open air within 40 m.
- Staircases must be equipped with smoke extraction systems.
- Floorings and furnishings of corridors and guestrooms must be of low combustibility and may not produce toxic gases.
- Floorings of staircases must be made from non-combustible materials.
- Full automatic fire detection systems and adequate alarm systems are necessary.
- The City of Vienna supported improvements by granting a financial support (35 % of the investments limited with € 36,300).

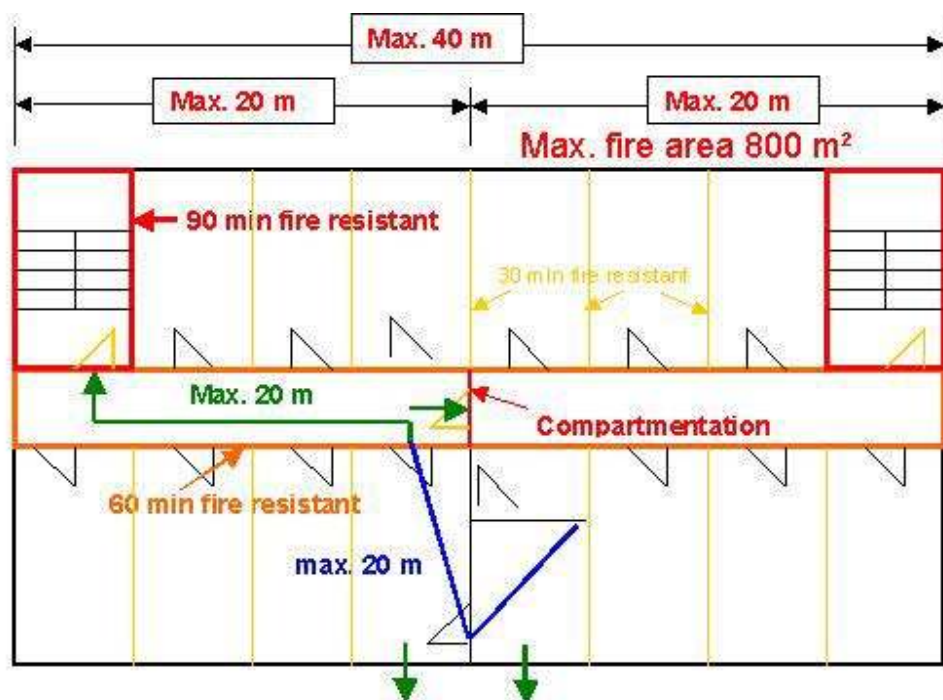


Figure 6. Scheme of compartmentation according to the technical guideline TRVB N 143

3. Preparedness plans and actions

As described in the earlier sections there have been no emergency plans or exercises. Training of the staff was missing. It is not usual to make fire-fighting exercises in hotels of the size of the Hotel Augarten (about 100 beds). Nevertheless the fire brigade was trained for fire-fighting room fires and the rescue of persons with ladders. Since Vienna has a powerful professional fire brigade and the fire stations are well distributed over the area of the city, 120 fire fighters were engaged in the intervention in a short time.

3.1 Lessons learnt

- Fire safety management plays an important role.
- An appointed person must be in charge of fire safety matters. He is responsible for:
 - Fire safety logbook.
 - Inspections, regular test of fire systems.
 - Cause maintenance.
 - Work out emergency procedures.
 - Fire training for the staff, exercises.
- The guests must be informed about the emergency procedures (alarm signal), the right behaviour in the case of fire and the means of escape.
- A leaflet on the door of each room gives this information. Additionally a verbal information of the guests is favourable.

4. Response/intervention actions

The hotel was situated at the corner of two streets. The fire brigade had the possibility to use ladders and turntable ladders for the rescue of people. Some persons were screaming for rescue although their life was not in danger. Some persons did not have the power anymore to draw the attention of the rescue teams. The leader of the intervention has to make the difficult decision who is rescued first. One young woman jumped from the first floor although she was not in danger. She died from the impact.

At the beginning of the intervention it was not possible to enter the building. The fire blocked the only access. After the fire had been tackled the fire fighters using breathing apparatus could search the building and found some victims in the corridors.

Nevertheless, the fire brigade was trained for fire fighting room fires and for the rescue of persons with ladders.

Since Vienna has a powerful professional fire brigade and the fire stations are well distributed over the area of the city (Fig. 7), 120 fire fighters were engaged in the intervention in a short time. Constant training of the fire fighters in fire fighting and the rescue of persons either using ladders and turntable ladders or inside the building using breathing apparatus and smoke hoods for the persons is imperative.

Despite all fire safety precautions a severe fire may occur and the fire brigade must be prepared.

4.1 Lessons learnt

- Persons screaming loudly must not be most endangered. The leader of the intervention regarding the possibilities has to decide who is rescued first.

- Although fire safety improves constant training of the fire fighters is necessary.
- A powerful fire brigade with short intervention time is imperative especially in a city with old buildings.
- The rescue of unconscious persons is very difficult. Sometimes the effective way may not be the gentle one.
- Since space at the emergency site is limited, the use of engines and manpower is limited to certain extent.
- Psychological support to the survivors, the bereaved and the intervention teams is necessary.

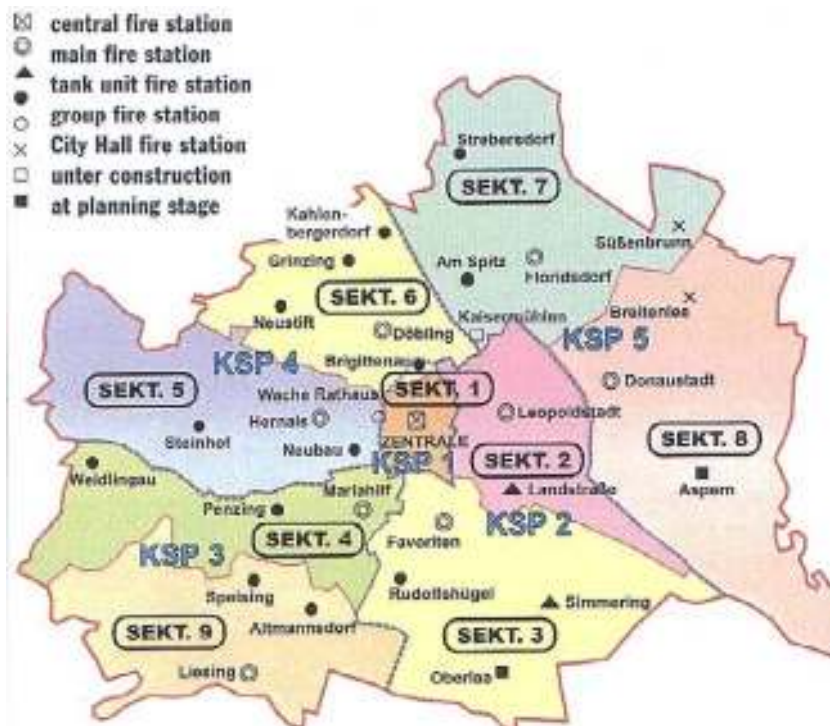


Figure 7. Distribution of the fire stations in Vienna (2003)

5. Dissemination of information to the public

The newspapers and the TV reported from this disastrous fire and the casualties caused by it. The fire led to a broad discussion about fire safety in buildings. People were alarmed of the danger of fires. But the fire fell into oblivion.

The demand of safety and the awareness of the danger of fire have increased in recent years. The public is informed about the right behaviour in the case of fire. Nevertheless, information to hotel guests about alarm signal, the right behaviour in the case of fire and the means of escape in different languages is still necessary

5.1 Lessons learnt

- Keep people aware of the danger of fire and smoke and inform them about the right behaviour in the case of fire.
- Information to hotel guests about alarm signal, the right behaviour in the case of fire and the means of escape in different languages is imperative.

6. Conclusions

Back in 1979, a disastrous fire occurred in the Hotel Augarten in Vienna. 120 fire fighters were needed for rescue operations and to tackle the blaze. 25 people were killed. 35 people were rescued by using ladders and turntable ladders. The premises offer an excellent example of bad hotel design. But the lessons were learnt. The major incident prompted new building and equipment regulations for hotels. Over 200 hotels were inspected in Vienna. Owners were forced to improve fire safety. The City of Vienna helped to fund the initiative.

With respect to tourism even old traditional hotels can comply today with the current state of fire safety (Fig. 8).



Figure 8. View of a traditional hotel in Vienna

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Fire at a senior citizens' service house on December 1999 at Maaninka, Finland

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1. Description of the event and consequences

Saturday evening on 4 December 1999 just after 23.00 hrs a fire broke out in a senior citizens' service house at Maaninka, a small town in central Finland, about 360 km north-east of Helsinki.

The service house had 20 flats each with one bedroom, living room, kitchenette and bathroom. In the same house were also day rooms for joint use and some other rooms. The total surface area of the building was 1,421 m². The house was one-storeyed and each of the flats could be entered either from the inside corridor or from the patio. The neighbouring house was a nursing home to which the service house was connected by a corridor (Fig. 1 and 2).



Figure 1. The senior citizens' service house seen from the north. The apartment where the fire broke out is located in the middle of the picture between the two garden swings



Figure 2. General layouts of the service house (Viljami) and the nursing home (Ollinniemi)

The service house provided sheltered housing for senior citizens. At the time of the fire most of the residents were patients moved there from the nursing home because part of it was under renovation. Ten of these patients could not walk without assistance and several had dementia. Altogether there were 23 occupants.

At around 23.00 hrs smoke alarm in one of the flats alerted via the security phone system. The alarm came to the mobile phone of a nurse in the neighbouring nursing home. Two nurses went to investigate the alarm and on the way were joined by a third person. When reaching the flat and after understanding there was a fire the other nurse left to raise the alarm and the other entered the flat with the third person. Despite their efforts they were unable to get the person, an elderly man out of the flat.

The fire station was located close by and the first unit arrived within 10 minutes from the 112 emergency call. Initial efforts were directed at rescuing the occupants, which turned out to be a troublesome task. Efficient fire extinguishing could only be started after about 1 hour and 45 minutes of the fire breaking out.

1.1 Consequences to people

In the fire five occupants died in five separate flats. The occupant of the flat where the fire started was badly burned. The occupants of the two adjacent flats and two opposite flats died of carbon monoxide poisoning.

One other occupant was treated in hospital for two weeks. Two fire-fighters had cuts resulting from window glass or roof cutting.

The occupants of the service house were evacuated to hospitals and health centres in the area. Later, most of them were moved back to the nursing home.

1.2 Damages and economic losses

The building was completely destroyed. Fire spread to the attic of the entire building and to the corridors and halls as well as to some of the flats. The rest of the flats suffered water and smoke damage of varying degrees (Fig. 3).

After reconstruction the service house was opened again in September 2000.

Economic losses and costs totalled almost € 2 million:

- Fire loss to the property € 1.5 million, which the insurance covered.
- Fire loss to the contents of the building € 44,000.
- Fire loss to the occupants' personal belongings was estimated at about € 13,500, which was mostly uninsured.
- Economic losses for about € 57,500 resulting from lost income from rents and service fees.
- Costs to the municipality about € 340,000 resulting from hospital and nursing care for the evacuated residents.

1.3 Cause of fire

The cause of the fire could not be determined with absolute certainty. Most probably the fire started as a table lamp fell down on the floor from a chest of drawers used as bedside table. The fallen lamp probably ignited a textile close by.



Figure 3. Fire investigators at the ruins of the burnt down service house

2. Prevention, protection and safety measures

The building was newly constructed and opened less than six months prior to the fire. The building was considered to conform to the relevant building regulations even though the chosen fire safety approach was incoherent. The design principles used were those of ordinary dwelling houses but partly also those of health care premises.

The building was divided into three fire compartments. Also the attic was divided into the corresponding fire compartments up to the roof. Each flat was structured as a fire compartment of its own (Fig. 4). Fire resistance was set at 30 minutes for all structures. Outside walls were timber-framed. Exterior walls were made of brick and interior walls were gypsum board. Separation walls between adjacent flats were of concrete. Roof construction was of prefabricated truss with metal-sheeted roof covering.

Fire compartmentation prevented spread of fire for the requisite length of time. In this case that was not enough since fire extinguishing could only be started after about 1 hour and 45 minutes. From the flat where fire started it spread to the attic and then to the corridors as well as to some of the flats.

Smoke spread quickly to other flats and to corridors through ventilation ducts. Ventilation was equipped with emergency stop but the push button was not localised. The door to the flat where fire started was closed but all four fire doors subdividing corridors were open in the initial phase. When the first fire-fighter entered the building at 23.17 hrs the west-wing corridor was already filled with smoke and the heat rise was noticeable. Smoke spread to other flats within 5 to 25 minutes as can be seen from the activation times of smoke alarms (Fig. 4).

Each flat had one or two smoke alarms that were connected to the security phone system. The building was not provided with automatic fire detection and alarm system nor was it protected by automatic sprinklers. There was no alarm system to notify occupants of an emergency nor was there any centralised means to report a fire other than using the telephone. The delay in alerting the fire brigade had great significance.

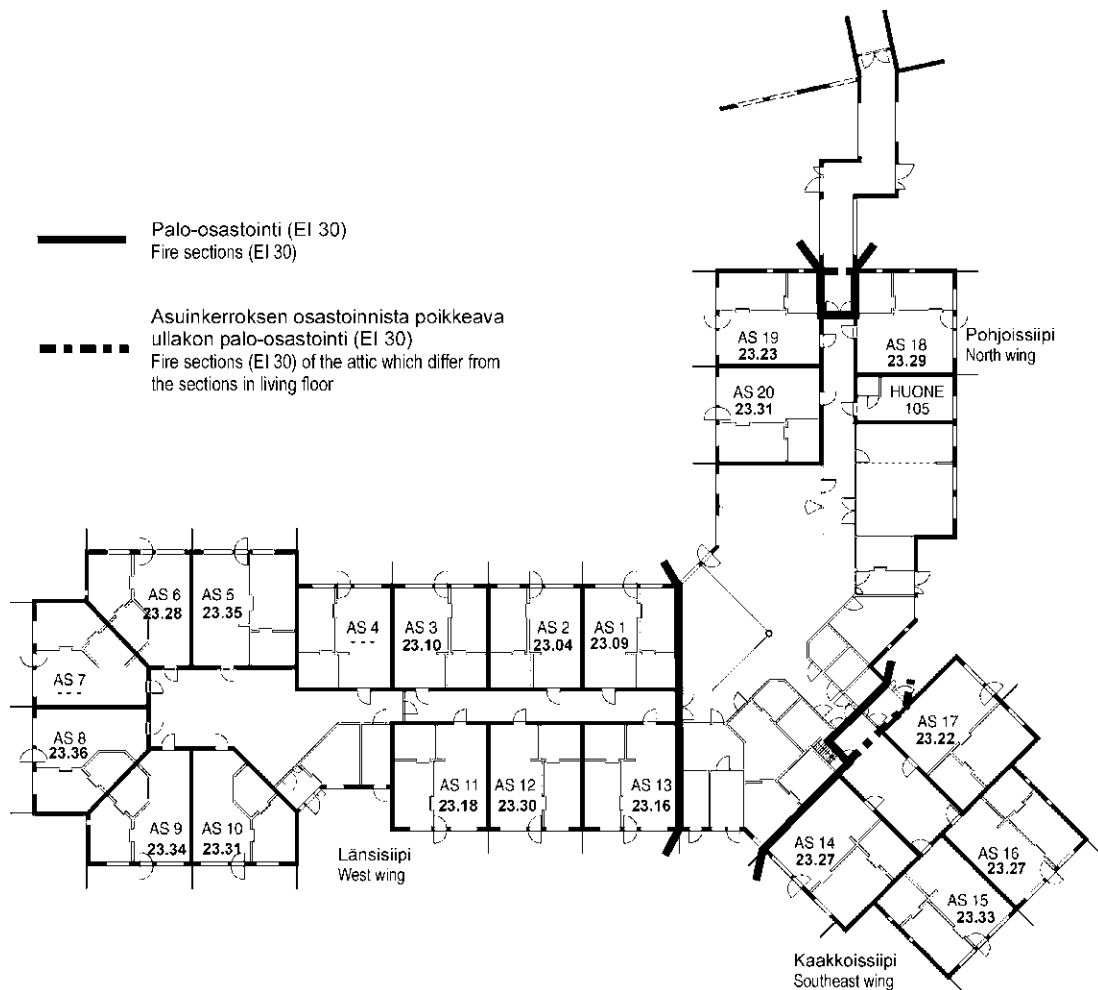


Figure 4. General layout of the service house. Fire compartments plus activation times of smoke alarms in the flats are marked in the picture

The flats had their entrance from the inside corridor. Each flat had also an exit directly to the outside of the building. The means of escape had been more than adequate if only the occupants had not been bedridden or otherwise unable to leave without assistance. Occupants' ability to act in the event of fire had been overlooked.

On the night of the fire there was no nighttime staff in the service house. The two night nurses of the neighbouring nursing home took care of the service house as well. They made there four to five control rounds per night and monitored the security phones occupants had. Arrangements to provide assisted escape proved to be insufficient as fire developed rapidly and total evacuation of the building was necessary.

2.1 Lessons learnt

- The design of means of escape and of other fire safety measures should be based on assessment of the risk to the occupants. In residential premises designed to be used by persons with disabilities or restricted mobility additional fire precautions are required especially when staffing does not correspond with what is necessary to provide assisted escape.
- Requirements for ventilation need to be adjusted for health care buildings in order to limit rapid spread of smoke.

- Automatic fire alarm system would have alerted the fire brigade earlier but only a sprinkler system covering the entire building could have prevented the fatalities.

3. Preparedness plans and actions

The safety documentation that is required by legislation was still under preparation. This meant that there were no emergency plans, staff training was yet to be arranged, there had not been any fire drills, etc. The staff was unprepared to deal with a situation like this.

In this kind of premises the local fire authority is to carry out a fire inspection before the premises are opened. After that, fire inspection is required at least once a year. In this case there had not been any fire inspections.

The fire brigade had no pre-incident plan prepared. They had been on location once in order to familiarise with the safety arrangements. The local fire brigade had no experience in large incidents of this type.

3.1 Lessons learnt

- In the event of fire the actions taken by staff are important. Staff should be trained and drilled in duties they are to perform in case of fire. There is often room for improvement in this respect.
- Fire brigades need to improve their emergency plans and have regular drills with the staff of the facilities.

4. Response/intervention actions

The fire station was located less than 1 km from the service house. Other fire brigades that were dispatched were located 21 km and 45 km away.

Emergency call was recorded at 23.10 hrs. First to arrive on scene were one fire-fighter at 23.17 hrs, then fire chief and two fire-fighters with one engine at 23.20 hrs and an ambulance with two men at 23.21 hrs. Next units arrived at 23.40 and 23.54 hrs with three engines and 11 fire-fighters. Later arrived yet district fire chief, one engine, one ladder and one hydraulic platform unit, two police patrols and altogether 13 ambulances.

At arrival the fire could not be located. Due to the limited resources available at the scene initial efforts were directed on rescuing the occupants. The search of rooms was completed at around 00.40 hrs, after which efficient extinguishing could be started. Fire could be prevented from spreading to the neighbouring nursing home and was controlled and mostly extinguished at around 02.30 hrs. Extinguishing continued through morning until 11.40 hrs.

Only two of the occupants managed to leave the building without assistance. Others were rescued from their flats via the doors leading to the patio area. Several of the occupants were found in their beds and carried out (Fig. 5).

Patients from the nursing home were evacuated as a precaution. Occupants of two neighbouring buildings were also evacuated and occupants of another building were notified of the fire.

4.1 Lessons learnt

- Emergency plans, fire risk assessments, etc. are in most cases unrealistic when determining the time and means required to evacuate premises where there are

persons with disabilities. Physical, mental or psychological impairments can significantly impede a person's ability to evacuate without help. Such impairments may also be of temporary nature such as persons with sedative medication.

- Fire brigades need to improve their state of readiness regarding fires in such high-risk facilities.

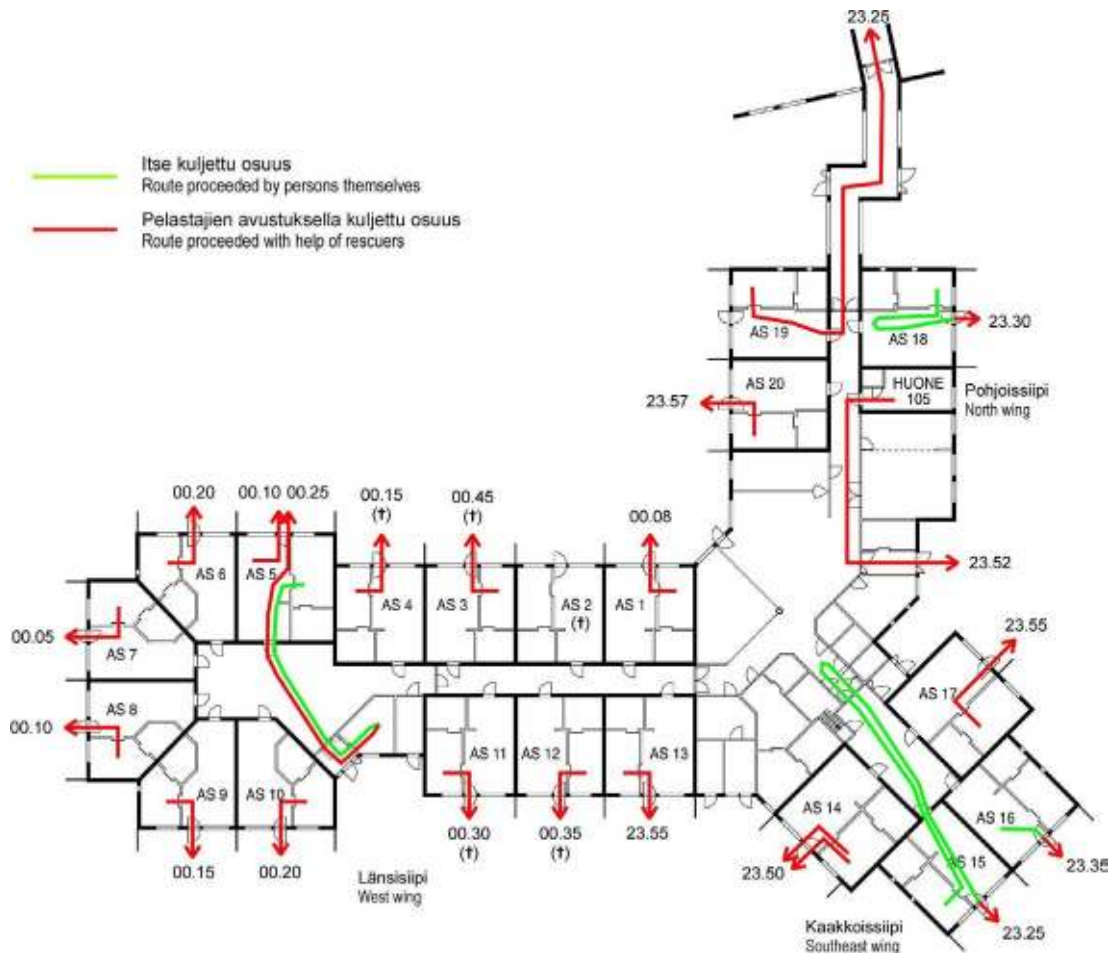


Figure 5. The time and routes by which the inhabitants were evacuated

5. Socio-economic implications

During the three months following this fire, 17 other fires occurred that had a great deal of similarities with this one. In those 17 fires three people died and six were injured. The special investigation commission that had been appointed after the first fire investigated also the other fires. Even though this report deals only with the fire at Maaninka the lessons learnt are drawn from the analysis of all these fires.

The investigation of all 18 fires revealed that fire safety in homes for the elderly and sheltered housing is not satisfactory as the need for assisted escape has not been taken into account.

In 2002 building regulations were modified according to the suggestions of the investigation commission. A fire safety analysis and detailed evacuation time calculations has to be provided for residential and health care premises designed to be used by elderly people or

people with disabilities or restricted mobility. In most cases the fire safety analysis has resulted in automatic sprinkler protection raising the standard for fire safety considerably.

In 2004 new legislation will come into force requiring a fire safety analysis retroactively also for existing premises. The results of the analysis should be used, where necessary, to raise the level of fire safety.

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Photographs are from the Accident Investigation Board.

Fire at the “A l’Innovation” Department Store in Brussels on 22 May 1967

Ivo Devijver

Fire Brigade Brussels, Belgium

1. Introduction

The “A l’Innovation” fire took place quite some time ago, but we must say - not without a certain degree of pride - that this event which shocked the whole world was the last catastrophic fire to take place in Belgium to date.

During a period of 50 years, over 60 major fires occurred in department stores. The most prominent of these fires were:

16 December 1932	Tokyo	14 casualties
28 October 1938	Marseille	50 “
18 October 1947	Christchurch (N-Z)	41 “
16 December 1958	Bogotá	83 “
1962	Nürnberg Kaufhof	21 “
14 July 1964	Tokyo	19 “
22 May 1967	Brussels Innovation	325 “

A study of these fires revealed the following shortcomings and causes of fire:

- The construction of the buildings did not include any fire prevention measures.
- There were no pictographs.
- There were not enough alarm systems.
- There were no automatic extinguishing devices.
- There was no in-house fire brigade.

Furthermore, the intervention of the fire brigade was affected by the fact that:

- The emergency call came in too late.
- It took too long to set up the rescue and pumping appliances due to:
 - The streets being too narrow.
 - The many vehicles parked in the streets.
 - The overhead tram power lines.
- The fire spread very quickly throughout the buildings, there was a heavy smoke production and people were panicking

The principal causes of the fires were:

- Carelessness of a smoker 28 %
- Failure of an electric installation 18 %
- Arson 18 %

Location of the seat of the fire:

- Working accommodation 40 %
- Sales department 28 %

- Stairwells, lifts, service lifts

14 %

2. Location

The “A l’Innovation” department stores are situated in a quadrangle formed by narrow streets (4 to 10 m wide), namely Nieuwstraat, Blekerijstraat, Dambordstraat and Koolstraat. The buildings have a total surface area of two and a half acres and a total volume of about 150,000 m³.

The main façade, which has three entrances and display windows, gives onto the Nieuwstraat, a well-known shopping street in Brussels (Fig. 1).

2.1 Origin of the “A l’ Innovation” department store

Towards the end of the 19th century, 4 Alsatians decided to set up business in Brussels. They decided upon a modest shop in Nieuwstraat. Not long afterwards, the 4 men acquired 2 former hotels and they entered into an agreement with the famous architect Victor Horta. This is how the first department store in Europe with a metal frame was conceived. The official opening of the “A l’Innovation” department store took place on 27 October 1902.

In 1967 “A l’Innovation”, which is centrally situated in Nieuwstraat, was composed of the following elements:

- The first building, designed by the architect Victor Horta, was erected in 1902.
- The second building, which was inaugurated in 1910, consists of a central part with columns and floors made of reinforced concrete, a large hall with atrium from the ground floor up to the fifth floor, in which the escalators were installed. The hall has a dome which consists of a metal structure with glass. This central section was the only part of the building to remain standing after the fire, which is not surprising since it was the only part of the building made of reinforced concrete.
- Part of the former “Rubens” hotel was preserved in its original state and constitutes the third building.
- The fourth and more recent building, five storeys high, has a partly metal and partly concrete structure. On the third floor of this building there is a self-service restaurant.

The department store is therefore a non-homogeneous complex consisting of 4 intercommunicating buildings. Each building is five storeys high at various levels, which implies that the floors are not situated on the same level. It is a complex of truly labyrinthian proportions.



Figure 1. Main façade at the time of the fire

The building complex has 5 stairwells and 5 non-protected lifts. The building has three main entrances for the public, which give onto Nieuwstraat.

Most of the floors are parquet floors; everywhere in the building there are false ceilings made of flammable material suspended from the original ceilings. The spaces between the ceilings are not compartmented. The ventilation systems, electric wiring and most of the pipes and cables are situated in this gap between ceiling and false ceiling.

The arcades and the various levels accessible to the public are situated in buildings 1, 2 and 3; the administrative services and storerooms are mainly situated in the fourth building. The two extremities of the façade facing Nieuwstraat are not accessible because of the aluminium panels attached to it.

3. Means brought into action

In all, 175 fire fighters of the Brussels Fire Brigade and fire brigades of the Brussels conurbation (Anderlecht – Elsenne – Molenbeek and Schaerbeek) were brought into action to fight the fire.

Civil Support sent 42 men to assist in the fire-fighting operations.

The fire brigades used 12 pumping appliances and 8 turntable ladders. Civil Support used 5 pumping appliances and 3 turntable ladders.

Some 15,000 m³ of water were used to fight this catastrophe.

The measures taken by the water supply company ensured that there was a sufficient supply of water, both with regard to volume and pressure (6 to 7 kg/cm²).

Ambulances were supplied by the 5 fire stations, the Red Cross, Civil Support, the Military Hospital and the police of Sint-Gillis and Sint-Joost-Ten-Node.

3.1. Casualties and damage caused by the fire

The death toll of this catastrophe was 325 people dead or missing. 80 people were injured and taken to various hospitals.

About 180 people were rescued by the emergency services (fire brigade, police, volunteers).

The total number of people present in the department store at the time of the fire was estimated at 1,700, at least 200 of which were customers of the restaurant on the third floor.

The total damages amounted to about 1.5 billion BEF (or about € 40 million), which in real terms corresponds to an amount of about € 100 million (Fig. 2).



Figure 2. View of the building after the fire

3.2 Where did the fire start?

According to the many eyewitnesses and testimonies, it is certain that the fire started on the first floor of the second building, in a small storeroom of the children's department.

These testimonies - some 20 - were given by people who were present in the children's department at the time the first signs of the fire occurred.

4. Intervention

4.1 Call out

It is true that the fire spread very quickly throughout the building, but it is also a fact that the emergency services were informed very late of the fire; the first signs of smoke could be seen at 13.20 hrs whereas it was only at 13.34 hrs that the emergency services received the first incoming call. That is 14 minutes! In the meantime the fire had spread dangerously in the space above the false ceiling. In addition, the department store's fire alarm was activated too late and was barely audible.

4.2 Intervention

The fire engines arrived on the scene very quickly. They were immediately aware of the seriousness of the situation. Turntable ladders were requested instantly to support the fire-fighting operation. When they arrived on the scene, they immediately started rescuing people on the side facing Nieuwstraat (Fig.3). All available means and manpower were used for carrying out the rescue operations, including turntable ladders and straight extension ladders. The rescue operation was seriously hindered on the other sides of the building. The turntable ladders remained stuck in Nieuwstraat because of the heat. The ladders which were sent in support came too late for many of the people trapped in the building. The transport of the injured to the hospitals was rather chaotic. Initially there was an imminent danger that the fire would spread to other buildings, but that danger could soon be averted. Thanks to the build-up of means and manpower, the fire was under control fairly quickly (after 2 hours). It can be concluded from the reports and the eyewitnesses' statements that all the rescue and fire-fighting operations were conducted in a fairly efficient and orderly manner.



Figure 3. Rescue of people by emergency services

Fortunately, nobody was hurt when part of the building came down round 16.00 hrs because the officer in charge had ordered everyone to remain at a safe distance from the building. There were no problems with the water supply since there were several waterpipes with a large diameter running under the streets surrounding the “A l’Innovation”.

We can safely state that, notwithstanding the scale of the intervention, the rescue and fire-fighting operations went fairly smoothly.

4.3 Could a catastrophe of such magnitude be predicted?

When we take a close look at the building, and on the basis of our current knowledge and mentality, we can safely state that this catastrophe could be predicted. Although in those days people were already familiar with concepts such as passive fire protection (compartmentalisation) and active fire protection (fire detection and sprinklers), these concepts were far from being generally applied. And what is more, there were not any fire prevention regulations or insurance companies that urged companies to take measures to prevent fires. On the contrary, the low insurance premiums and the fierce competition between insurance companies rather favoured a different attitude.

5. Prevention

In this respect the Innovation was clearly not up to the mark. Far from it! The following elements were conducive to this catastrophe:

- No compartmentalisation. The storerooms, where lots of flammable materials were stored, were not separated from the shopping section.
- The monumental staircase and the atrium created a chimney effect, as a result of which the smoke and fire had free play.
- The store did not have an automatic fire extinguishing system (sprinkler).
- The internal (and also external) fire alarm call came too late, which had fatal consequences.
- As the lighting system cut out very quickly, many people were unable to find the emergency exits.
- The front windows were closed off (aluminium panelling).
- The stability of the building in the event of a fire was deplorable; many metal girders were not protected.
- A fire detection system had been installed only in the display windows and the roof.
- The store was full of highly flammable material (Fig. 4).



Figure 4. Flammable material at a display window

6. Lessons learnt

Notwithstanding its many shortcomings, the Innovation Department Store satisfied the statutory fire prevention regulations of that time.

We can safely state that the loss of lives as a result of this catastrophe has not been in vain.

22 May 1967 is the start of a double reorganisation:

6.1 The Brussels fire brigade

- The Brussels conurbation (1,000,000 inhabitants) has always been protected by various fire brigades (Brussels – Anderlecht – Schaarbeek – Molenbeek – St-Gillis – Elsene). The fire led to the merger of all these different fire brigades into a unified fire brigade of the Brussels conurbation in 1973. This unification certainly increased the efficiency, reduced the intervention time and improved the collaboration between the fire fighters.
- The standard turnout equipment of the Brussels fire brigade consists of:
 - Outpost: 1 pumping appliance
1 turntable ladder
 - Central fire station: 1 pumping appliance
1 turntable ladder
1 command vehicle
1 ambulance

The turntable ladder vehicle always drives in front of the pumping appliance.

Experience teaches us that:

- When ladders are required, it is essential that they are immediately on the scene.
- A correct positioning of the turntable ladder vehicles can be vitally important.

6.2 The Belgian fire brigade

- There was no national standard for equipment and material.

The result was that certain fire brigades could not connect their fire hoses to the available fire hydrants because the couplings did not fit.

This situation has been remedied by:

 - Centralised purchasing
 - National legislation and Royal Decrees
- The rather chaotic transport of injured persons made the policymakers reflect on the necessity of developing medical contingency plans.
- To optimise the interventions of the fire brigade, each brigade is to draw up special intervention plans with regard to buildings which constitute a potential hazard.
- The “A l’Innovation” had a first intervention team. However, its organisation and the training of its members bears no comparison with present-day standards. Today, members of a first intervention team have the opportunity to receive training at the NVBB or at one of the ten provincial fire training schools.

6.3 Prevention

- Until 1967 there was no national standard or legislation regarding the prevention of fires in Belgium. It took until 1972 (i.e. 5 years) before the first Royal Decree was issued with regard to high buildings (> 25 m).

Since that time, several other Royal Decrees were issued (hereby the Royal Decrees on buildings):

- 1974: Homes for the elderly
- 1979: Hospitals
- 1994: Buildings of medium height (>10 m) and high buildings (> 25 m)
- 1997: Low, medium-height and high buildings

In addition, several Belgian standards were issued regarding:

- Medium-height and high buildings
- Fire reaction
- School buildings
- Hotels
- Aeraulic installations
- Smoke and heat removal
- etc.

The first and very important standard is the NBN 713.020, regulating the resistance to fire of building components. This standard was published in December 1968 (one and a half years after the fire).

This standard lays down the test method, testing apparatuses, elements to be tested, the test procedure and the classification of the building components.

Bearing in mind the catastrophic fire of 1967, this standard implied a tightening of the regulations and the test requirements were among the strictest in Europe. There was a deep-rooted fear that history would repeat itself.

As it is known, standards are merely rules of good professional skill. They do not carry any legal obligation.

- The A.R.A.B. regulations (General Regulations concerning Protection at Work) contain a number of articles on the prevention of fires. The main article (art. 52) has been adapted and extended on a regular basis since 1968.
- In 1967 the NVBB (National Association for Protection against Fire and Burglary), was founded on the initiative of the Belgian insurance companies, united in the Professional Association of Insurers (BVVO). The NVBB aims at improving the measures, means and techniques for the prevention of fires and burglaries and the protection of people and property. The NVBB's activities cover six domains: training, information, regulations, certification, laboratories and inspections. The NVBB is collaborating with government authorities to work out statutory regulations regarding the prevention of and the protection against fire and burglary. The NVBB also plays an active part in the committees and working parties set up by standardisation institutions on a national, European and international level.
- The Greater Brussels Council has done its bit as well. As a result of the federalisation of Belgium, the regional authorities are partly competent in matters of fire

prevention. In 1973 the Greater Brussels Council published its “Title XIII”, which imposes a number of fire prevention measures to all places open to the public, starting from the ordinary pub or corner shop. A key factor is the Rf-partitioning of these buildings.

6. Conclusions

The causes of this catastrophic fire have not been discussed. It has never been completely cleared up. Some sources speak of an attack in view of the fact that it happened during the American week. However, nobody claimed responsibility for any attack. A more likely cause of the fire is the failure of an electric installation in the false ceiling of a storeroom in the children’s department. Notwithstanding the magnitude of this catastrophe, it took about 5 years for the political authorities to take effective measures, partly because of the pressure exerted by public opinion and the media. It would be far more realistic to refine legislation on a regular basis. The fact remains that legislation on fire prevention always relates to new or renovated buildings, without any retroactive effect. This means that buildings which are not altered in any way are not subject to any obligation to improve their fire prevention properties, which implies that the fire risk is not reduced at all and that there is a growing imbalance between new and existing buildings.

Here lies an opportunity for Europe to improve – within certain limits – fire prevention measures in existing buildings.

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The 7 December 2002 fire in the city of Trondheim, Norway

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1. Description of the event and consequences (including a short historical background)

On Saturday 7 December 2002 a fire occurred in a restaurant complex in the centre of the city of Trondheim in Norway. The restaurant complex consisted of two connected restaurants – discotheques bearing the names News and Ricks.

Trondheim is a 150,000 inhabitants old city on the Norwegian western coast (Fig. 1). The city is a centre for technological education and research in Norway, with a solid foundation in the natural sciences. The whole city reflects the activities of the students.



Figure 1. Location of the city of Trondheim

The city of Trondheim has a significant part of the Norwegian history and culture. The city was founded in the year 997 and it was the first capital of Norway. It is still the city where new regents (Norway is a kingdom) receive their ceremonial blessing. One of the largest wooden buildings in Europe's Nordic countries, now called the Royal Residence, is situated only a few hundred metres away from where the actual fire took place.

This short description of the city or rather the centre of the city leads to the fact that no other city in the Nordic countries has as much wooden architecture as Trondheim. After a major fire in 1708 city planners proposed that stone and brick would have to be the material of choice in central parts of Trondheim. However, one still continued to build houses with

wood. A fire in 1899 destroyed 18 wooden houses leading to new ordinances banning wood as a building material in densely built areas. Similar ordinances were also passed in most large cities in Norway due to calamitous fires occurring around the turn of the century.

1.1 Description of the start of the fire

The accident was reported at 10.45 hrs to the regional communication central dedicated to handle fire alarms in the county of Sør-Trøndelag. The main fire station in the city is located only a couple of blocks away from the restaurant complex where the fire occurred.

The fire brigade entered the fire scene only some three and a half minutes after the fire was reported.

The fire fighters were told that there was a fire in the kitchen (both the restaurant and the discotheque shared the same kitchen facilities). The fire was told to be in an oil fryer that included heated cooking oil (e.g. for French fries). As this fire occurred on a Saturday morning the restaurant was preparing for the opening hours. The chef filled 5 to 10 litres of cooking oil in the oil fryer, adjusted the switch to 200°C, and went to change his clothes in the nearby locker room. The chef had been away from the kitchen some 5 to 10 minutes when he noticed an unusual smell and went back to the kitchen. He then observed flames from the oil fryer up against the ventilation system in the kitchen.

Failing to put out the flames using a fire extinguisher, he had to withdraw from the kitchen. At that moment the fire produced heavy black smoke and flames. A short time after the evacuation of the kitchen the staff heard a pop. The investigation of the fire showed that the pop could have been related to the triggering of the automatic sprinkler system installed in parts of the building. It is stated almost for certain that the sprinkler system was triggered due to the fire in the oil fryer.

1.2 Human consequences

No one from the public or evacuated people were injured during the fire. One fire fighter was hospitalised due to a falling wall of bricks, but he was not seriously injured.

No lives were lost. Quite a few people lost their income when their place of work was destroyed. The densely built wooden houses mainly consisted of various shops, hairdressers and restaurants.

1.3 Economic losses

The overall economic losses were more than 200 million Nkr (Norwegian kroner), equivalent to more than € 24.5 million. This sum includes the insurance companies costs, and does not include costs generated by the response of the police, fire brigade and ambulance services.

2. Prevention, protection and safety measures

2.1 General measures

According to the Norwegian act of fire prevention the owner of a building is responsible for the fire safety. This includes technical measures, such as automatic sprinkler systems or fire alarm systems (if such measures are required), emergency lightning systems and portable fire extinguishers or fire hoses. Fire safety also includes risk analysis and planning by the

owner, including the assigning of a dedicated person responsible for fire prevention in general, exercises and emergency reaction.

2.2 Actual object

As stated earlier the actual buildings were densely built in materials made out of wood. The buildings were constructed after the city fire in 1841. The densely built houses with the addresses Nordre gate 11 and Dronningens gate 14 were probably made as log houses, separated with logs up to the ridge of the roof. The lack of construction drawings from that period makes it difficult to state for certain that this is the actual type of construction. However the findings indicates that the log construction has been present.

The houses or the blocks were built around a kind of back yard meant for deliverance of goods. Through the years the densely built houses have been partly changed and partly reconstructed. Traditionally originally constructed walls of logs inside the houses have been removed and given place to more modern style of construction. For instance, originally mounted windows have been removed and replaced with more modern windows.

The kitchen where the fire started was originally not a part of the wooden constructed house, but constructed as an addition or a kind of annex. Through the last handful of years it “grew up” a sort of ventilations room on top of the annex.

This room should according to both former and actual building regulations have been a separate fire compartment. This was not the case. The room was only a simple wooden construction, barely to keep the ventilation aggregates free of snow in the wintertime.

During the investigation one could not find any documents that could state the situation of this probably simple wooden construction surrounding the ventilation aggregates.

The fire started in the oil fryer and managed one way or another to spread, possibly through the ventilation shaft from the kitchen to the construction surrounding the ventilation aggregates.

The sprinkler system has probably managed to suppress the fire in the kitchen (combined with the fact that the fire after some minutes burned out the cooking oil), but the system has not been able to stop the fire from spreading to the rest of the house and later to several other houses.

The way the fire spread shows that large open attics in densely built wooden houses rapidly spreads fire (at first gasses and heavy smoke spreads in the large open area in the attic, secondly and well known the gasses ignite).

2.3 Lessons learnt

- Fire in densely built houses can only be stopped with proper prevention measures.
- Fire inspectors must give these type of buildings, especially the ancient densely built houses, a thoroughly inspection and clarify that the owners live up to their responsibility according to national fire regulations.
- Large open attics must be sectioned properly.
- Properly installed sprinkler systems (they must cover the whole building not only parts of it) will prevent fires from spreading. They often extinguish the fire as well.

3. Preparedness plans and actions

3.1 General plans and actions

Densely built wooden houses must have continuous attention on preparedness measures on fire safety. Such measures are especially vital for owners of restaurants, discotheques or other public establishments in such buildings. The owners must have a thorough knowledge of their obligations according to national and local fire regulations.

3.2 Actual object

The owner of the actual object where the fire had its origin was aware of his obligations as pointed out in the national fire regulations. He had for some years developed the restaurant and discotheque complex both by reconstruction of the building by a dialogue with the Trondheim building authorities and the Fire Prevention Section in the Trondheim Fire Department.

The dialogue with the local building authorities and the local fire department focused mainly on life safety measures. The fire department demanded according to the regulations that the number of guests allowed in the establishments should never exceed more than approximately 600 persons. The establishment however had the opinion that the number of guests could be nearly 1200. This dispute went on for some years involving the local municipality authorities as mentioned earlier, various advisers, architects and a law firm. At the time of the fire the acknowledged number of guests still were not more than approximately 600.

This dispute led to the fact that nobody paid attention to the “ventilation room” and the fact that that room never met the standard regulations concerning fire resistance for such a construction.

3.3 Lessons learnt

- There must be continuous focus on evacuation exercises.
- Emergency plans must be constructed according to the principles of the health, environment and safety act and the fire regulations.
- Establishment staff must be regularly drilled on how to deal with a fire situation.
- Chefs and other staff members designated to work in a kitchen must regularly exercise on how to handle a fire in heated cooking oil (e.g. what kind of extinguishers are effective).
- Staff handling security must be drilled regularly in how to evacuate a large number of people.

4. Response/intervention actions

4.1 Actions

The Trondheim Fire Brigade had its first unit on the scene less than four minutes after the alarm call. Supporting units arrived only seconds later. The at the time possible first line response counted 20 fire fighters located in three fire stations in or around the city. In addition to the professional full time fire fighters, the fire brigade also has a fourth fire station manned with part time fire fighters whom is called upon when needed.

45 minutes after the alarm call the fire fighting team consisted of 25 fire fighters including officers. In addition, fire brigades from a neighbourhood municipality assisted alongside with originally off duty fire fighters from Trondheim Fire Brigade. The specially trained and equipped Civil Protection Defence Unit (FIG) was also called upon. They made arrangements for continuous water supply from the river and the harbour area.

Totally more than 100 fire fighters and other personnel participated in the fire fighting actions.

At the time the fire took place, Norwegian authorities had a pilot project led by the Ministry of Justice going on, testing the new communication system TETRA. The fire brigade had implemented the new radio system both at the alarm call centre and in the response units.

4.2 Lessons learnt

- The local fire brigade was not properly trained on how to deal with such an event.
- There was a lack of sufficient planning in the fire brigade. (The fire brigade's two main divisions or sections – the Prevention Section and the Fire Fighting Section – had not communicated well enough over the years prior to the event).
- Pre-planning for fire fighting must consist of both knowledge from the fire prevention inspectors and the fire fighting staff.
- Successful fighting of fire can only be achieved through cooperation between prevention measures and traditional fire fighting knowledge.
- The communication system TETRA, which at that time was installed in Trondheim, passed the test and functioned well.

5. Dissemination of information to the public

The event was investigated both by the local police who has a responsibility for doing so, the Norwegian Fire Research Laboratory (NFRL) and by the Directorate for Fire and Electrical Safety (DFES). In addition, also a building advisor has produced a report after the event. The reports are only available in the Norwegian language. The reports from NFRL and DFES are available through the websites www.dsb.no and www.nbl.sintef.no.

6. Main lessons learnt on a national basis

- There must be a proper balance between focus on prevention measures concerning life safety and the safety of objects and material goods.
- In the future ancient densely built wooden houses should be protected from fire by the use of automatic sprinkler systems (both inside the buildings including the attics but also protecting the frontage of the buildings).
- The local fire brigades must make plans for how to deal with the spreading of fire in densely built wooden houses.
- The local fire brigades must pay attention to exercises on how to fight fire in densely built wooden houses.
- The new communication system TETRA passed the test and functioned well.

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The great fire of Edinburgh, Scotland, UK

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1 Description of the event

On 7 December at 20.11 hours and 20.13 hours, eight fire appliances were mobilised by Fire Brigade Control from stations at Tollcross, McDonald Road, Liberton and Marionville to two apparently separate incidents.

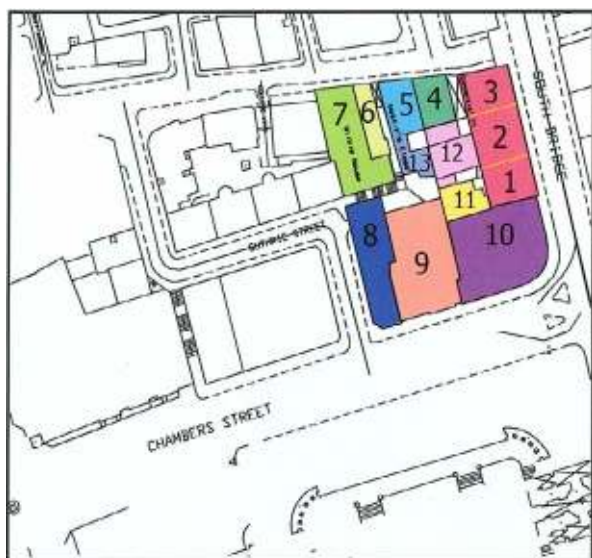


Figure 1. Plan showing the buildings involved in the Cowgate fire

Fire calls are received from a collector service via an automatic fire alarm call to Edinburgh University property at Premises No 1 (Fig.1), 80 South Bridge (timed at 20.11 hrs).

A second call is made via the 999 operator from a licensed property (Premises No 12), La Belle Angele, 11 Hasties Close (timed at 20.13 hrs).

Finally, a third call is made by the Manager of Leisureland (Premises No 3), 84 South Bridge, reporting smoke within his property (timed at 20.15 hrs).

On that night appliances of The Lothian and Borders Fire Brigade were mobilised to what was to become one of the largest fires in the Brigade's history involving a range of 18th, 19th and 20th century

buildings, many of historic interest. The fire involved 5 interlinked buildings containing 13 premises, which included licensed premises, nightclubs, shops and offices (Fig. 2). The footprint of the building measured approximately 60m x 60m, with buildings ranging from 5 to 7 floors, serviced from adjoining road levels at ground (Cowgate) and fourth floor (South Bridge). The buildings were of traditional construction for their period, and consisted mainly of stone walls, timber floors, part pitched, boarded and slated, part flat roof construction. Over a number of years renovation had taken place within a number of buildings which had resulted in knock through access between buildings for persons and additional services. In addition, there were numerous void/ducted areas that ran vertically and laterally throughout many of the buildings. These renovations inevitably played a major part in the very rapid spread of fire throughout the buildings.

2. Intervention

A command team briefing was held with the Fire Commander, and being appraised of the ongoing situation, the decision was made to withdraw crews for a safety briefing. This decision was based on information indicating a severe fire within floor and ceiling voids, as seen by thermal imagery cameras and from crew de-briefings.

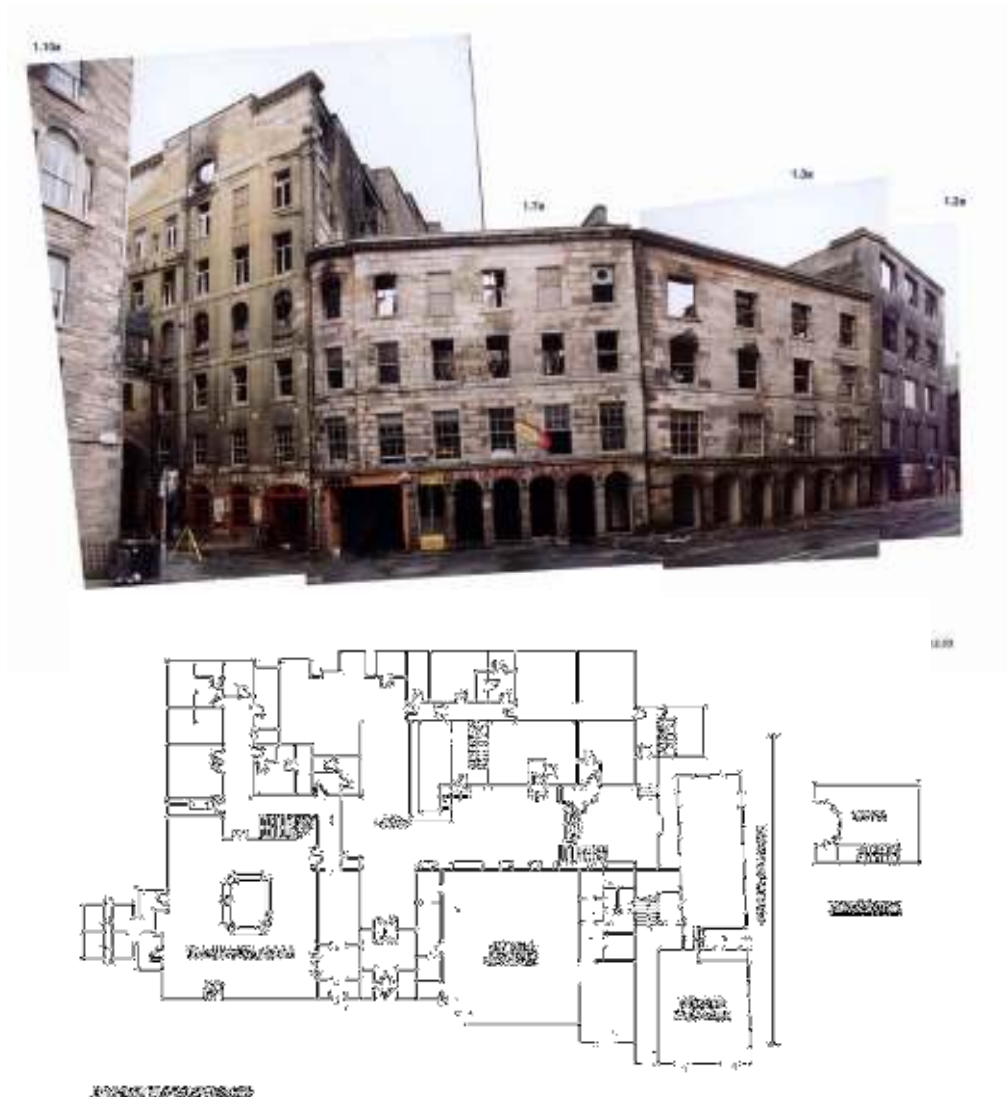


Figure 2. Buildings involved in the fire and Cowgate ground floor

Following more information coming forward as to the conditions inside the premises, and on the visible indication from outside the premises, a decision was made to evacuate the complete building and contain the fire by the use of Water Towers from the Cowgate.

Due to the extensive building(s) footprint and the congested nature of access it was decided to concentrate firefighting efforts in surrounding the fire and minimising fire spread to adjacent heritage buildings. Firefighting operations continued throughout the night and at 11.09 hours on Sunday, 8 December 2002 the Stop message was sent to Brigade Control.

Dampening down of the fire continued for a further forty-eight hours, with elements of concern centring around the stability of the buildings due to the loss of vertical and horizontal supporting structures.

2.1 Resource management

The demand on Lothian and Borders Fire Brigade resources was substantial. From 20.11 hours on the 7th December to 18.13 hours on the 11th December in excess of 180 individual appliance movements occurred. From the initial firefighting teams to the final crew leaving after assisting with damping down operations. Arrangements were left in place for the return of Height Appliances to assist the demolition company.

At the incidents height, twelve pumping appliances, five height appliances and two specialist appliances attended the Cowgate and South Bridge with Firemaster Brian Allaway assuming command of the incident with over eighty firefighters tackling the fire. Additional height appliances from Fife fire and rescue services and Strathclyde fire brigade attended under mutual assistance arrangements [1].

The Brigades command structure was instigated, resulting in the mobilisation of twenty four senior officers over the weekend. Officers returning to duty on a voluntary basis supplemented the command structure. Thirteen officers were initially deployed to the incident and the brigades logistical support centre.

During the evening of the 7th, four control staff members dealt with all appliance and officer mobilisation. In addition to effectively dealing with all other fire calls. Over the weekend 7th and 8th Control dealt with 150 other fire calls. The Brigade maintained a fire cover response throughout the incident.

3. Contributory factors and related lessons learnt

- The rapid development and spread of fire may have been restricted to a smaller area, or avoided, had adequate barriers including,
 - building separation
 - fire stopping
 - fire compartmentation been in place.

The lack of suitable fire stopping led to unrestricted fire spread throughout the adjoining properties, both vertically and laterally.

- The fire continued via large void areas, some one metre in depth, at floor and ceiling levels and through openings in walls, such as doors and windows which were inadequately fire stopped or enclosed during changes to the properties.
- These changes included the conversion, of what appeared to have been a courtyard bounded by old tenement properties, into licensed premises.
- The rapid unseen spread of fire and the dangerous conditions that were developing within the First Floor level and surrounding area resulted in the emergency evacuation of all the building and the re-siting of all fire-fighting appliances to a safer area.

4. Prevention, protection and safety measures

4.1 Automatic fire detection/alarms/fire suppression

- A sprinkler system had been de-commissioned during renovations and conversions for the change of use to Places of Entertainment. Had the system remained in place, and been fully operational, the fire damage to the surrounding properties would have been significantly reduced.
- Had smoke detection been installed throughout the Building of origin the Livingroom Public House the additional early warning may also have reduced the damage to the surrounding properties.
- The actuation of the manual fire warning system installed in the premises resulted in the safe evacuation of all members of staff and members of the public.

The fire was eventually detected by automatic smoke detectors in a remote area of the surrounding properties owned by Edinburgh University

4.2 Prevention

The collaboration of fire safety officers, operations planning and owners of premises and buildings, where similar conditions may exist should be encouraged beyond fire certification or licensing of individual properties. This collaboration should involve adjoining properties even if they fall out with any formal or legal remits, and should include The City of Edinburgh Council, City Development, Building Control and Planning Departments.

Fire safety officers should look at the issues of compartmentation and fire separation of existing buildings during inspections.

Lessons learnt

- The existing and the creation of new void areas for services combined with the frequent change of occupiers can perhaps go some way to explaining why the development of the fire between buildings was so rapid, a fact collaborated by firefighters in their eyewitness accounts.

5. Legislative Controls

These premises have been subject to the Fire Precautions Act 1971, The Licensing (Scotland) Act 1974 and other forms of licensing inspection. The buildings which comprise the development range from areas initially built in the 18th century and added to over the years until around 1940's when the major use of the upper areas was as a large department store. The Edinburgh World Heritage Trust has commissioned a detailed report by Addyman Associates Ltd.

As a department store, the premises were under the control of one owner who had sole responsibility for the development, and of the internal arrangements, subject to the Building Controls of the time. During this period, a sprinkler system had been installed and subsequent use of the premises became better controlled by the Offices, Shops and Railway Premises Act 1963. Like most other premises of this type, competition was great and in the late 1970's the department store closed and the building was acquired for development.

In 1980, in one of the first multi use commercial developments to be planned in the City of Edinburgh utilising an existing building, the developers encouraged a number of businesses into the development.

As a result of liaison between Building Control and the Fire Authority in Edinburgh, the initial redevelopment was well documented, and plans of the individual premises were clearly delineated. During the next few years, many of the original occupiers vacated or altered their premises. Some premises have had as many as 5 occupancy changes over the year, with subsequent occupiers making minor alterations to suit the new use of their area. Each successive change, whilst recorded in the Fire Certificate, changed the original layout, with some occupiers discovering that lower floors for which they were paying sizeable business rates were not being put to profitable use. To reduce the rateable value, these areas were closed off, reducing the occupier's rateable value. These areas were now effectively removed from certifiable use and fire certificates were amended accordingly.

This practice became more common and so the internal shape of the building was altered piece by piece. Those areas that had been sealed off from the original building now formed sizeable void areas through which service ducts and cables ran.

Further internal changes whilst not classified as structural changes, necessitated changes to ventilation, an action which required access being made to the previously sealed void areas. Fire Authority involvement in this area was restricted to commenting on fire stopping through floor levels.

6. Fire Investigation

As part of the Brigade's incident management structure, a fire investigation officer was mobilised to the fire on receipt of the first assistance message. In line with established protocols it was decided to form a team and to invite all interested parties to share in the investigation process. With the fire brigade acting as the lead, a group of investigators representing the police forensics and the many insurance companies who covered the business losses were able to gain access to the buildings for a preliminary investigation on the Monday morning following the fire.

As the site was deteriorating and the safety of the investigating team was being compromised investigators had to abandon all efforts to gain access to the area of interest. Eventually the Health and Safety Executive put in place additional control measures for the safety of the demolition site. Most of the buildings were occupied at the time of fire, which made it possible for the team to confirm that their preliminary findings on the seat of the fire were accurate. The investigators were able to track down the seat of the fire to an area in and around a series of voids, which had once contained a lift and ancillary mechanical equipment. Some of these void areas contained ducting and electrical equipment, which the team were keen to inspect further. However, the safety issues previously mentioned made it impossible to remove sections of walls and flooring.

7. Risk assessments (the future)

How do we implement the Existing risk assessment model to multi owned multi purpose properties!

7.1 The Risk Assessment Model

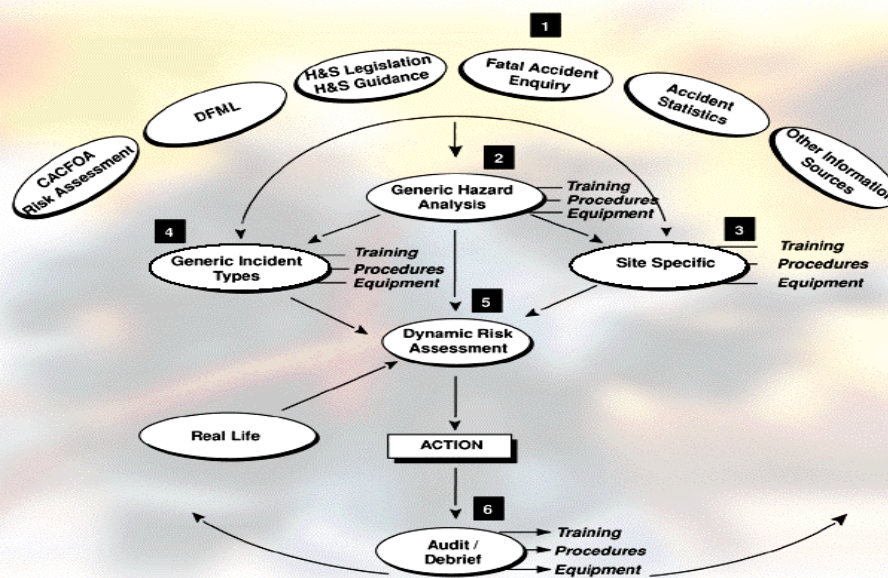


Figure 3. Risk assessment model

The Risk Assessment Model (Fig. 3) is a simple and easily understood display of the steps taken in the process of Operational Risk Assessment [3]. It represents the methodology of the process and the links between each part, all of which are of equal importance and are interdependent as components of the process. Within the process of Operational Risk Assessment is Dynamic Risk Assessment which is that made by personnel in operational situations. The dynamic assessment is supported by the other components of Operational Risk Assessment and in fact the process is designed to enable personnel to make valid dynamic assessments.

The flow of information between the steps in the process are the links which tie the process together and indeed make it work. Without the links and communication paths (formal and informal) each step would become a barrier rather than a building block and it is reasonable to suggest that communication is vital to Operational Risk Assessment.

The model displays outcomes of various steps. These outcomes are the development of Training, Operational Procedures and Equipment which are measures used to control or eliminate hazards and in turn reduce the likelihood of these hazards causing harm to personnel and other groups exposed to risk.

The outcomes contribute to the aim of the process which having set goals, culminates in managing the "safe person concept".

The aim is achieved by building and maintaining a systematic process of Operational Risk Assessment.

Information Sources

The process relies on information feeding in from many sources both theoretical and empirical, formal and informal. Some of the information sources allow the Brigade to confirm the accuracy of our work and provide checks and cross references. These information sources feed on to Generic Hazard Analysis, Generic Incident Types and Site Specific.

Generic Hazard Analysis

This aspect of the Operational Risk Assessment process can rightly be regarded as the fulcrum upon which the system is built. Hazards to operational personnel are identified and systematically analysed. Thirteen areas of operational hazard were identified and analysed. Each of these operational hazards have a group of constituent hazards all of which, if not controlled, can endanger operational personnel. An example of this is Hazard Analysis 1. Firefighting. The group of constituent hazards are heat, steam, smoke, gases, flashover, back draught and structural collapse. The risks are the harm these hazards can cause and to whom.

Identification of existing control measures and subsequently any additional control measures are areas which are heavily influenced by the information sources which, allied to the knowledge and experience of the officers carrying out the analysis, give the exercise validity.

The Generic Hazard Analysis in turn feed into Site Specific Assessment, Scenario Type and Dynamic Risk Assessment.

8. Site Specific Assessment

The Site Specific Assessment is the identification of premises which present:

- Potential risk to Firefighters
- Potential risk to the environment

This is achieved by applying the generic risks to individual premises and giving these premises a score. The higher the score means the more hazards Firefighters may face in these premises hence greater priority is given to higher scoring premises.

Three categories of premises will be established as

- High,
- Medium
- Low.

Categorisation depends upon score so the highest scoring premises are rated High Hazard, next are Medium Hazard premises down to Low Hazard premises.

High Hazard premises will be inspected by operational personnel and a comprehensive database of information, including plans, will be compiled. When the opportunity permits, personnel will carry out exercises and drills on High Hazard premises.

Medium Risk premises will fall into a category of Generic Incident Type and as such will have a framework operational procedure developed. This will facilitate a safe system of work for similar premises not qualifying for a Site Specific Inspection but where the hazards are broadly the same.

Low Hazard premises are those which have a group of "core" generic hazards such as Firefighting, potential collapse of structure and electricity. It may be heights, machinery and radiation. In any case the hazards are accounted for by training which is designed to take account of identified generic hazards. These premises may be visited at the discretion of a Watch Commander, as could Medium Hazard premises.

9. Integrated risk management (IRM)

Since 1824, we have been delivering a fire and emergency rescue service to the public. This service has grown and developed into the organisation you see today – a sophisticated and modern fire and emergency service. The standards that we have used to decide how many fire stations we need and where to site them were defined by Government.

Standards for other services, such as response to road traffic accidents and line rescue incidents, we determine ourselves.

There are three main principles to IRM [2]: firstly, we are being asked by the Government to become an organisation which puts prevention first. The idea is that our main aim will be to prevent fires and other emergencies from happening in the first place.

- Prevention – We need to ‘drive down the risk’ of fires and other emergencies.
- Intervention – Only where we have been unsuccessful in prevention will we need to provide an operational service to deal with the consequences.

This is, of course, a reversal of where we have come from.

The second strand of IRM is that the three types of service we provide

- Operational intervention
- Community safety prevention

- Technical fire safety protection

All three services need to be more joined up. At the moment, each of the three services operates relatively independently, with its own priorities and standards (the best known one being the Standards of Fire Cover, mentioned earlier, which helps us decide how many fire appliances and stations we need). The idea is that each of the three services can work together to achieve our aims. So, for example, if we spot an operational ‘hot spot’, rather than build a new fire station, we might choose to increase our level of community safety activity in that area. Our first priority should be increasing community safety work

The third strand of IRM is that we should have a much better understanding of the risks in our area. Our current structure of operational stations is based on standards of fire cover which looked simply at the types of buildings in an area and their density. IRM asks us to look at a much broader range of things, for example:

- Population
 - Where are the people?
 - Are they old or young? And does their distribution change at different times of day?
- Historical data where do our fires and other emergencies tend to occur?
 - Where are people injured
 - or killed in fires and why?
- Our heritage
 - Where are the important sites
 - Which ones require particular attention
- Hazardous materials and processes
 - What type of environmental risks are around?
- The risk to our own staff
 - How can we minimise the risks our staff face at work?

The Scottish Executive will be asking the Fire Brigade to develop an Integrated Risk Management Plan [2]. Some of the work will need to be done at a Scottish level and some of it locally. Arguably, our biggest task will be to change the culture of our organisation to one which puts risk reduction first. This is something which every member of the Brigade will need to work at. Five years from now, the public should think about our organisation as one that exists to minimise risk to the community, and is only there to attend emergencies when the risk reduction has failed.

Right now, we as a Brigade are beginning to look at what data we have about our area that we can use to build a ‘risk map’, and a team of people will be working on this. This team will create the risk map, evaluate all of our current activities and then think about how we might improve on what we do. The outcome of all of the work will be the Integrated Risk Management Plan. The Fire Board will then be able to say: ‘this is how we see the risks in our community and here is the range of services we will provide to reduce that risk and deal with any emergencies’. The plan will be a living document, developing and changing as we get better at understanding our risks and recognising changing community needs. And we, as an organisation, will need to continue to evolve to ensure the plan is implemented efficiently and effectively.

References

- [1] Fire services act 1947.
- [2] *Integrated Risk Management Plan*. Office of the deputy Prime Minister.
- [4] *Operational risk assessment model*. Lothian and Borders fire Brigade, Edinburgh, UK.

Appendix 1

LIST OF PROPERTIES DESTROYED BY FIRE

ADDRESS OF PROPERTY	OWNERS NAME AND ADDRESS
1. 77 South Bridge, Edinburgh Camping and Outdoor Centre	
2. 80 South Bridge, Edinburgh Department of Artificial Intelligence	University of Edinburgh
3. 82 South Bridge, Edinburgh The Bridge Jazz Bar	Voyager Pub Group Ltd
4. 84 South Bridge, Edinburgh Leisureland	Lothian Entertainments Ltd
5. 11 Hasties Close/209 Cowgate, Edinburgh La Belle Angel	
6. 233 Cowgate, Edinburgh Ticketing Services/Art In Partnership/The Graphics Company/16K Designers/Paul Ferranx/Rags/Create/Lois	Cowgate Arts Ltd
7. 235 & 237 Cowgate, Edinburgh Club Loca The Livingroom	Luminar Dancing Ltd
8. 227 & 229 Cowgate, Edinburgh The Guilded Balloon	Festival Inns Ltd

LIST OF PROPERTIES DAMAGED BY FIRE, SMOKE OR FIRE FIGHTING WATER

ADDRESS OF PROPERTY	OWNERS NAME AND ADDRESS
9. 1, 1A Chambers Street and 74/75 South Bridge, Edinburgh Biblos The Beat Jazz Bar	Festival Inns Ltd
10. 1B Chambers Street, Edinburgh Richer Sounds	Richer Sounds Ltd
11. 3 Chambers Street (Including Adam House), Edinburgh	University of Edinburgh
12. 76 South Bridge, Edinburgh Gossip Clothing	
13. 207 Cowgate, Edinburgh	Festival Inns Ltd

**LIST OF PROPERTIES EVACUATED DUE TO
DANGEROUS NEIGHBOURING BUILDINGS**

ADDRESS OF PROPERTY	OWNERS NAME AND ADDRESS
37 & 39 Guthrie Street, Edinburgh	University of Edinburgh
200 Cowgate, Edinburgh Occupiers:-	Edinvar Housing Association
Capital City Homes address as per owner	
Scottish Council for Single Homeless C/o 54A Fountainbridge (4 th Floor), Edinburgh, EH3 9PT	
Scottish Refugee Council C/o 5 Cadogan Square, 170 Blythswood Court, Glasgow, G2 7PH	
Community Services Volunteers C/o Age Concern Scotland, Leonard Small House, 113 Rose Street, Edinburgh, EH2 3DT	
37 South Bridge, Edinburgh	1A Maciver Opticians Ltd
85-87 South Bridge, Edinburgh Occupiers:-	Linkage (Scotland) Ltd
Department of Social Work per Director, Shrubhill House, Shub Place, Leith Walk, Edinburgh, EH7 4PD	
Department of Environmental and Consumer Services per Director, Chessier House, 500 Gorgie Road, Edinburgh, EH11 3YJ	
38 South Bridge, Edinburgh Occupier:-	
Piemaker	
40/41 South Bridge Occupier:-	West of Scotland Securities Co Ltd
Forbidden Planet (Scotland) Ltd 168 Buchanan Street, Glasgow, G1 2LW	
42 South Bridge, Edinburgh Occupier:-	
Emport Apparell Ltd C/o Xile, Princes Mall, 3 Waverly Bridge, Edinburgh	
45/46 South Bridge, Edinburgh Occupier:-	
Costcutter Express Mr Jaffin, 125 Lothian Road, Edinburgh	
34/35 South Bridge, Edinburgh	Unknown
43 South Bridge, Edinburgh	Unknown

The large fires of public utility premises in Poland

Tomasz Gartowski and Rafał Porowski

National Headquarters of the State Fire Service, Warsaw, Poland

1. The 21 September 1975 fire at the Central Department Store in Warsaw

In this fire there were no victims, three persons were lightly wounded and the material losses amounted to 130 mln zloty (equivalent to € 27.8 million).

The building of the department store was opened in 1951. It has eight above-ground storeys and two at underground level. The ceilings were built of reinforced concrete, leaning on columns made of the same material. The total area was 22,000 m² (trade area 8,500 m², warehouse area 2,600 m²). Dimensions of the object: length: 70 m, width 40 m, height 35 m.

The internal walls were made of brick. External walls of the building were glazed in 90 %. The individual storeys were joint by four staircases, six passenger and freight lifts, the ventilating shafts, as well as, from the ground floor to the fifth floor, escalators in flammable casing (the laminated hardboard).

In ceilings there were openings for the construction of escalators, which were 12 on 4 m.

In the building there were the articles of fabric, clothes, footwear and household goods. The fire load was estimated at 170 kg/m², according to Polish fire safety standards.

There was lack of internal fire-resisting division in the individual sale halls (1,550 m² each). The staircases go directly to the halls of sale. Also the escalators were not separated from the halls of sale.

There were also the following means of fire protection in the building: fire extinguishers, internal hydrant installation (eight hydrants in the each hall of sale), fire detectors (melting detectors in the ceilings of the halls of sale), twenty-four-hour supervisory service (without the possibility to entry into the halls of sale and storerooms). There was no smoke removal system inside the building and no emergency lighting.

The building had an emergency and evacuation plan. There were some firefighting and evacuation exercises. The staff was trained in the case of fire and how to lead evacuation.

The fire was noticed in the evening on 21 September (fortunately on Sunday, where there was no people inside the building) at 20.07 hrs by passers-by when the black smoke began to come outside the fifth floor.

When the first fire brigade engines arrived on the scene the fire zone had covered the third and fourth floors as well as the shafts of escalators from the first floor to the upper part.

After several minutes windowpanes fell out from the frames. Flames took outside and the fire had covered the whole third as well as the fifth floor (Fig. 1).

Firefighters could not enter from the staircases to the halls of sale because entries were closed by bars. The fire hose on the escalator was broken off when the escalator had moved itself actively, and firefighters had to evacuate.

The street hydrants did not provide a suitable quantity of water for firefighting purposes. It was necessary to raise the pressure in the municipal water supply system as well as bringing water from other parts of the city. This caused the fire to spread on half of the third floor, on

several exhibition stands on the second floor as well as on inaccessible storerooms on the sixth floor.

At about 23.00 hrs the fire was taken under control and it was put out at 00.30 hrs. 428 persons and 44 units of the fire brigade participated in this rescue operation. To put out the fire the fire brigade used 18 firefighting jets and 14 water monitors. [2],[7].

The cause of the fire was a failure of the not switched off mechanism of the escalator. Earlier recommendations after the fire inspection were not put into practice [5].

After the fire, the department store was restored in 1977 and equipped with modern sprinkler system with a special water reservoir, fire detection system and automatic smoke removal system.



Figure 1. The fire in the Central Department Store was the biggest one in Warsaw after the Second World War

1.1 Lessons learnt

Operation

- According to the time of fire beginning (Sunday evening) it was not necessary to evacuate people which permitted avoidance of victims.
- Necessity to equip the fire services in cities with ladders and hydraulic platforms with the possibility of evacuating people (platforms, evacuation conveyors) and to equip with heavy firefighting vehicles.

- Necessity to change the firefighting equipment (the overpressure breathing apparatuses for the whole crew, torches, new protection suits).
- Necessity to build up an effective net of the fire hydrants in cities.

Prevention

- Changes of building regulations according to roads of evacuation.
- The requirement of installing in department stores solid extinguishing equipment, smoke removal systems, fire alarm systems, sprinkler systems and building monitoring connecting to the fire service.
- Obligation of emergency lighting system inside of such buildings not to cut visibility during evacuation in case of fire.

2. The 31 October 1980 fire at the Psychiatric Hospital in Górna

In the fire in 18 Men's Ward of the Regional Hospital for Nervously and Psychically in Górna Grupa (Bydgoskie Province) 55 in-patients died, 29 persons became injured including the nurse and firefighter. From 319 patients of the hospital 266 were saved. Firefighters stopped the fire spreading on the whole hospital area. The hospital building was the former theological seminary, built in the 1924. The four-storey building has the roof wooden construction. The roof was covered with tiles. Ceilings were made of wood. External and internal walls were made of brick. Rooms were numerous. 50 beds with only one exit on the corridor. The part of the evacuation exits was walled up. The main (and also the only one) staircase about 160 cm wide was not separated.

In the building there was no fire detection and alarm system, no internal hydrant net, no emergency lighting system. There were only portable extinguishers. Every storey was locked overnight, which made very difficult and even impossible patients evacuation. To lead the evacuation it was necessary to make a hole in the wall leading to the second staircase.

The building had an evacuation plan. The staff was trained in the case of fire and how to lead evacuation. Firefighting and evacuation exercises were not put into practice.

The fire started in the late evening hours. Many patients were physically inefficient or under calmative or were sleeping. There was no possibility to lead out many of them because they fell down in "stupor". After evacuation many of the patients came back to well-known for them (and in their opinion) safe rooms in the building. Others were terrified and ran in all directions in neighbouring fields. There was frosty weather, temperature was -7 °C and patients were in pajamas only. The fire spread on the fourth storey of the northern part of the building and very slowly on the attic construction. Inside the building there was high density of smoke. There was not enough number of breathing apparatuses for firefighters and at all for the other participants of the rescue operation. Thick and black smoke from the burning polyurethane foam mattress contained prussic acid.

After about 1.5 hours the ceiling was burnt and the fire had progressed on the roof construction intensively. Fire was put out at about 06.30 hrs. In the rescue operation took part 28 sections of the fire brigade (135 firemen), soldiers, the police (together 280 persons). The cause of the fire was a leak of the chimney. Earlier recommendations after the fire inspection were not put into effect. [1].

After the fire the building was restored and equipped with fire detection system. Nowadays it is again the theological seminary.

2.1 Lessons learnt

Operation

- Necessity to change the firefighting equipment (the positive gauge pressure breathing apparatuses for whole crew, torches, new protective suits).
- Necessity to change equipment of firefighting vehicles (the positive pressure ventilators, high-tension lighting poles).
- Necessity to change the rules of fire service disposal to such fires.
- Necessity to put into practice firefighting and evacuation exercises to verify rescue and emergency plans.

Prevention

- Change of building regulations according to evacuation roads, etc.
- Requirement of installing in hospitals fire detection and alarm systems, emergency lighting and connection to the fire service.
- Prohibition of usage of mattresses made of polyurethane foam in hospitals.
- Testing of materials on emission of toxic substances from the combustion.

3. The 23 April 1998 fire at a hospital in Szczecin

In this fire there were no wounded persons; the material losses amounted to € 3 million (exchange rate).

The building was built in the end of the 1920's with destination as a hospital. Walls were made of full bricks. The part of ceilings over the third storey and construction of the roof were wooden. The roof was covered with metal sheet.

Compartments on the highest storey were separated by gypsum – cardboard plates. Over part of the compartments was executed the wood ceiling with the blind ceiling. In the rest of the building ceilings were made of reinforced concrete.

In the building there were portable extinguishers and internal hydrant net. There was neither fire detection and alarm system nor emergency lighting system.

The building had an evacuation plan. The staff was trained in the case of fire and how to lead evacuation. Firefighting and evacuation exercises were not put into practice.

The fire was noticed at 03.20 hrs in the night in the central part of the main building. The wooden ceiling burned-through; the corridor was in smoke. After 40 minutes the area of the fire was 800 m². In the final phase, the area of fire reached 1,600 m² as a result of lack of access to the burned part of the loft (over the blind ceiling) (Fig. 2).

The firefighters and other staff of the hospital evacuated 630 persons, including newborn children as well as pregnant women. There were no injuries. Officers in charge and the hospital staff all the time had the knowledge about the number of evacuated persons and their surnames.



Figure 2. Night fire in Hospital in Szczecin

When evacuation was finished the medical apparatus and equipment of the hospital were removed and protected. Effects of the water destruction of hospital rooms were kept to a minimum. The losses were estimated at about 13 million zł. (equivalent to some € 3 million)

In the evacuation and rescue action took part 223 firefighters (57 vehicles), 210 policemen, 140 soldiers and 30 teams from the ambulance service. The cause of the fire was arson by a mentally unbalanced patient [6],[0].

After the fire the building was restored in 2001 and equipped with modern fire detection system.

3.1 Lessons learnt

Operation

- It is very important to dispatch maximally large forces well appointed and trained.
- The most important thing is evacuation and really in the second phase extinguishing, which allow avoidance of victims.
- Necessity of introduction of modern firefighting and rescue vehicles.
- Necessity to put into practice firefighting and evacuation exercises to verify rescue and emergency plans and to recognize such buildings.
- Necessity to have special trolleys for wounded persons.
- The alarm system should permit to access the same information for any incident at any time to different services.

Prevention

- The change of building regulations.

- Implementation of risk assessment methods for prediction of any threats.
- Requirement of installing in hospitals fire detection and alarm systems, emergency lighting and connection to the fire service.
- Testing of materials on emission of toxic substances from the combustion.
- Use of fire retardant materials.

4. The 27 April 1981 fire at the gastronomic complex "Kaskada" in Szczecin

In this fire there were 14 victims and no persons were wounded.

On 27 April 1981 in the Szczecin three-storey gastronomy complex "Kaskada" the fire broke out. In a few minutes flames covered the whole building. 14 persons lost their life. Firefighting and rescue operations lasted eleven hours.

The cubature of the building was about 9,000 m³. Walls were made of full bricks. The bearing concrete pillars were about 52 cm in diameter. Internal walls were in different construction: concrete plates, full brick, partly luxfer tiles. In some compartments there were wooden walls. The cellar and individual storeys were separated by heavy plate. In the ceiling between the ground floor and the first floor in the part for consumers, over the dancing - circle there was a 10.5 m diameter opening.

The flat roof in one fourth of its surface was made of reinforced concrete. The other part was made of the wooden framework. Roofing in this part was made of copper plate.

Four ventilation shafts (30 x 30 cm) joined all storeys. Elevations of two external walls of the building were glazed in 95%. Other walls were made of brick with individual windows.

The electric wiring system, especially in restaurants, was in poor technical condition. The conductors were arranged under carpets and on flammable facings of walls as well as behind the flammable elements of interior decorations without any protections. Joining stepped out "on kink".

The curtains made of steelon were hung near the windows.

Individual storeys were assigned to: the cellar: boiler room, the ventilation centre, the kitchen and social store-houses; the ground floor: restaurant about a surface of 298 m², kitchen from subsidiaries, change room; first storey: restaurant about a surface of 385 m², room of subsidiaries; second storey: restaurant about a surface of 461 m², room of subsidiaries; third storey: restaurant about a surface of 378 m², compartment of subsidiaries.

In the building there were together 600 consumptive places. In all restaurant halls there were a lot of easily inflammable materials. In the hall on the ground floor all walls in their whole height were lined with plastic plates (of polystyrene). On the parquet floor the fitted carpet was arranged on spongy foundation. On the ceiling there was fibreboard.

In the hall on the first storey walls were covered by tapestry. In the hall on the second storey there were boxes made of the pine wood with a canopies.

The fire load of the hall, taking into account all flammable materials, reached 2000 MJ/m².

There were 52 internal hydrants on the staircase landings as well as foam and halon extinguishers. There was no fire detection and alarm system, nor emergency lighting system and nor smoke removal system inside the building.

The building had an evacuation plan. The staff was trained in the case of fire and how to lead evacuation. Firefighting and evacuation exercises were not put into practice.

The fire started in the corner of the hall on the ground floor and spread near the floor. The fire was notified to the fire brigade at 08.07 hrs, and in three minutes later had already covered all storeys. The fire on the higher storeys spread across the opening in the ceiling, staircases as well as through ventilation shafts and from outside the building across the glazed walls. Thermal radiation caused catching to fire two vehicles parked near the building as well as trees in distance of 30-40 m (Fig. 3).

Since the moment of rise of the fire to the spreading on the whole building flowed away 10 – 12 minutes. It made impossible any workings by the fire brigade inside the building. They managed to save from the third storey only one person. The rescue operations were limited only to application of water and foam jets and to defense of neighbouring buildings which were in a big fire hazard. The fire was put out at about 18.50 hrs.

Inside the building there were found 14 victims with 6 pupils from the gastronomy school. All victims died as the result of poisoning with toxic products of combustion.

15 sections of the fire brigade took part in the rescue operation (100 firefighters). The cause of the fire was a short-circuit of electric wiring [4].

After the fire ruins were not reconstructed.



Figure 3. Fire in the Gastronomic complex "Kaskada" in Szczecin was the most tragic after the Second World War

4.1 Lessons learnt

Prevention

- The change of building regulations (evacuation roads, dress up interiors, solid installations extinguishing, etc.).
- Regulations in the field of fire safety and construction elements for such buildings.
- Testing of materials on emission of toxic substances from the combustion – obligation of standards requirements.

5. The 24 November 1994 fire at the show hall in Gdańsk Shipyard

The fire caused seven victims, 200 persons seriously wounded and material losses of 350 mln zloty (equivalent to about € 75 million).

On 24 November 1994 in the show hall of the Gdańsk Shipyard an evening concert was organized, to which about 1500 persons came, mainly children and young people.

This building was built in 1920 (pre-war smithy/forge). It was part of the complex of shipyard buildings and adhered directly to the street. From 1956 it has been used for boxing, volleyball and different sport events. Dimensions of object: length 65 m, width 40 m, height 8.3 m.

The hall was one storey. External walls were made of steel pillars in the skeleton construction spaced every 1.5 m. Spaces between the pillars were made of brick. The construction of the roof was of steel coated from wood with steel purlins, rafters girders and several layers of asphalt roofing. The floor of the hall was covered with wooden parquet. Near the walls were placed platforms for spectators knocked with wood. Under tribunes there were prepared magazines for the sport equipment.

Inside the hall many flammable elements were placed. On the back wall of the hall a group of wires and technological pipelines were suspended. There were six entrances to the hall but only one was available for the public, the main from the street side.

To the exit there was a narrow 7 m long corridor with stairs up and down, with double doors. In the first exit the lateral door leaf was closed. In the second exit the central door leaf was closed. The corridor was made by gratings. The central grate was open and the side grate was closed. In the narrowest place the corridor was only 2.5 m wide.

Inside the building there were 52 internal hydrants as well as foam extinguishers. There was no fire detection and alarm system, emergency lighting system and smoke removal system inside the building.

The building had an evacuation plan. The staff was trained in the case of fire and how to lead evacuation. Firefighting and evacuation exercises were not put into practice.

The concert was protected by one firefighting vehicle from the Shipyard Fire Brigade (5 firefighters). The concert began at about 18.00 hrs. The main lighting of the hall was switched off, only scene headlights were shined.

At 20.55 hrs firefighters on duty had noticed flames on the tribune No. 2. The fire spread very quickly in all directions. It was necessary to evacuate all participants (in this moment about 700 people) of this concert. The concert service called all the people with the loudspeakers to go out through the main exit. The temperature and smoke layer were grown intensively. The spectators got into panic. People wanted to go outside treading down each other in only one narrow exit.

Because the Shipyard Fire Brigade did not cope with the spreading fire the municipal fire brigade was called in. 32 sections of the fire brigade took part in the rescue action (91 firefighters). Their first task was to carry out evacuation of people which were tumbled and imprisoned in the exit doors and gave first aid for the injured. Several hundred of burnt and panic-stricken persons were imprisoned near bars blocking the doors.

After cutting the bars and the fence separating the pavement in the front of the building from the tram - track-way menaced men were free (Fig. 4).

The ambulance service gave first aid to the injured. Many persons were burnt, with broken hands and legs. Taxis and private vehicles also took back wounded people to 11 hospitals. Among the injured people one trampled teen girl was found.

Just after evacuation of all people from the main exit, at 21.14 hrs the roof of hall collapsed. This made impossible any internal work and check whether there were more victims under the rubble. After collapsing the construction of the roof, wins over from walls bended down inwards the hall at an angle of 45 degrees, tearing off the conduit fittings – how it turned out – gas.

The fire was so intense that caught fire of the port crane, which was at a distance of about dozens of metres.

Intensive firefighting operation permitted to take the fire under control till 00.16 hrs and to put it out at 06.04 hrs.

After the site of a ruin was searched the body of a television operator was found. It was one more deadly victim. He has filmed the interior of the hall till the last moment.

As a result of burns five persons died in hospitals. From over 200 injured, dozens experienced very serious body scalds (even 70%), faces, heads and hands. Many of them did not recover till the present day. The cause of the fire was arson [3],[9].

After the fire ruins were not reconstructed.



Figure 4. Fire in The show hall in Gdańsk Shipyard was one of the biggest ones after the Second World War

5.1 Lessons learnt

Prevention

- Rigorous fire safety inspections of buildings.
- Control of keeping fire safety regulations, especially for evacuation roads and emergency lighting systems.
- Testing of materials on emission of toxic substances from the combustion process.

Organization and training

- The establishment of the integral medical rescue system with close cooperation with the Emergency Medical Service and the State Fire Service.
- Implementation of regulation for better fire protection of mass-events.

6. The 9 March 1985 fire at the National Theatre in Warsaw

In this fire there were no victims, although seven persons were lightly wounded and the material losses amounted to 500 mln zloty (equivalent to about € 107 million).

The National Theatre is part of the complex of the Great Theatre. The building has five storeys. It was rebuilt after the Second World War in 1949. The dimensions of the building: length 70 m, width 60 m, height 25 m. Individual storeys are assigned to: in the underground: the ventilation centre, stores for decoration; in the basement: the stores for decoration, the change room; on the ground floor: revolving scene about surface of 400 m², auditorium for 889 seats, the carpenter room; on the first floor: auditorium balcony, wardrobe; on the second floor: the second auditorium balcony, wardrobe, the library, hall of rehearsal/tests; on the loft: the painting room. The roof with steel structure, lined with boards, roofing of metal sheet.

The building was equipped with internal hydrant installation which worked smoothly. The sprinkler system on the scene was put out of order. The smoke removal system was inefficient. There were also portable extinguishers and emergency lighting system. The scene was separated from the auditorium by the iron curtain. The curtain did not lowered at the time of the fire.

The building had an evacuation plan. The staff was trained in the case of fire and how to lead evacuation. There were some firefighting and evacuation exercises with participation of the fire service.

On Saturday 9 March 1985 there was a rehearsal on the scene, in which the whole actor team participated. In the auditorium there were about 100 persons. Around the scene there were decorations from combustible materials.

The fire under revolving scene was noticed at the time of the rehearsal, at about 12.15 hrs. It was impossible to put it out neither by internal water hydrants nor with fire-extinguishers.

At the moment of arrival of the fire brigade the whole scene was hugged with the fire (the surface was 400 m²), as well as the under scene room and a part of stores of decoration. The interior part of the building was totally smoked. 28 persons were removed by turntable ladders of the fire brigade from balconies, windows and from the roof of the building. One unconscious woman was carried out from the internal staircase.

Three persons (including one firefighter) were poisoned with smoke and four were burnt. Office rooms, the carpenter room, the painting room, the museum as well as the building of the Great Theatre were directly in big fire danger. The street hydrants did not provide a suitable quantity of water for firefighting purposes. It was necessary to upward the pressure in the municipal water supply system as well as bringing water from other parts of the city and from the Vistula River.

To put out the fire the fire brigade used 52 water and foam jets. 51 sections of the fire brigade took part in the rescue operations (305 firefighters) (Fig. 5).

The fire was put out at about 22.30 hrs. Cubature of the fire was about 25,000 m³. In the fire there were burnt: the revolving scene with equipment, two balconies of the auditorium, the wardrobe, the roof over the auditorium (surface of about 400 m²), stage decorations in store rooms and the lighting and acoustic devices in the auditorium. The cause of the fire was probably arson. Earlier recommendations after the fire inspection were not put into effect [8],[11].

Restoration was finished in 1994. The building was equipped with modern sprinkler system with a special water reservoir, fire detection system and automatic smoke removal system.

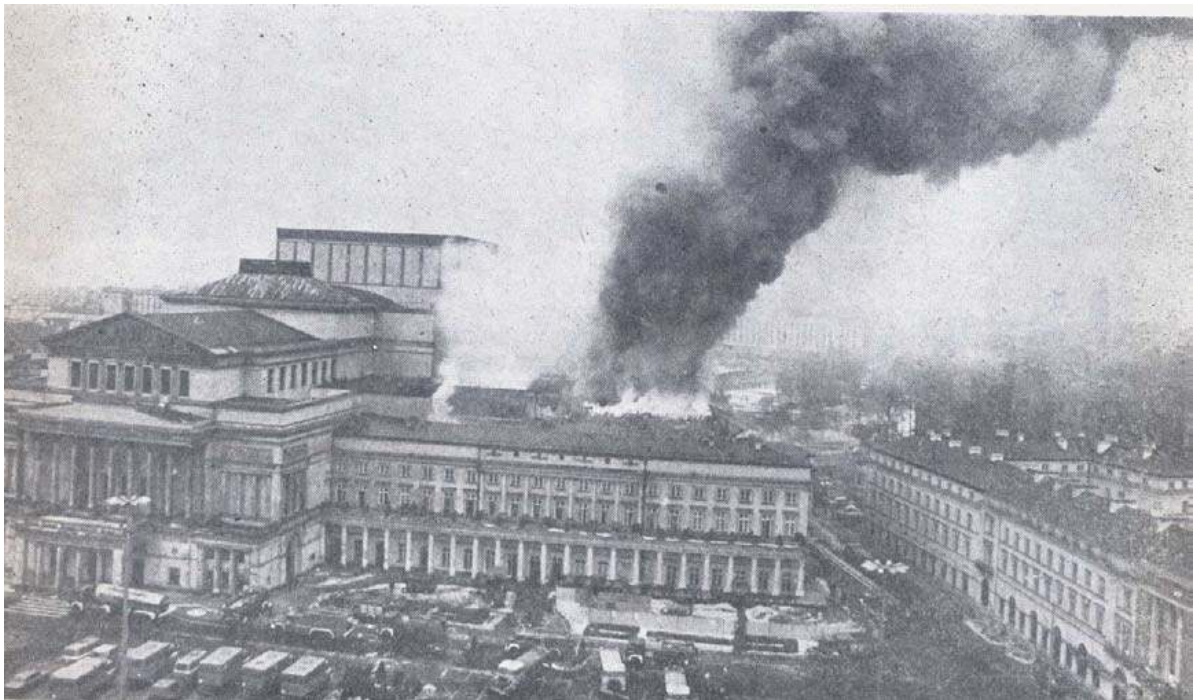


Figure 5. Fire in the National Theatre in Warsaw

6.1 Lessons learnt

Operation

- It is very important to dispatch maximally large forces well-appointed and trained.
- The most important thing is evacuation and really in the second phase extinguishing, which allow avoidance of victims.
- Necessity to put into practice firefighting and evacuation exercises to verify rescue and emergency plans and to recognize such buildings.

- The alarm system should permit to access the same information for any incident at any time to different services.
- The fire service should renew firefighting and rescue vehicles.

Prevention

- The requirement of providing the theatres with smoke removal systems, fire detection systems, evacuation lighting systems and connection to the fire service.
- Testing of materials on emission of toxic substances from the combustion process.
- Rigorous fire safety inspections of buildings.
- Control of keeping fire safety regulations, especially for evacuation roads and emergency lighting systems.

7. Summary and new fire safety regulations in Poland

The State Fire Service in Poland has just finished work on the new modified fire safety regulations according to European Union requirements. They include especially:

- Ordinance of Ministry of Infrastructure on technical requirements of buildings, in fire safety context.
- Ordinance of Ministry of Interior on fire protection of buildings and other areas.
- Ordinance of Ministry of Interior on fire access routes and water supply.

There is also possibility for fire prevention officers to have entitlements to close buildings if they do not follow fire safety standards according to inspection documentation. There is also an obligation of providing all safety documentation of buildings, including technical approval of fire equipment and extinguishers, rescue plans, evacuation procedures. There is an obligation to prepare “the fire safety instruction” for such buildings including:

- general fire protection conditions of buildings,
- approval system of fire protection devices and equipment,
- ways of leading evacuation in case of fire,
- technological process and all storage threats,
- dangerous substances in building,
- practical emergency exercises.

The fire safety instruction should be updated once every two years and also after every change of building construction and storage process. Very important for safety is the improvement and approval of documentation and of course checking the fire monitoring system in the building if it exists.

Evacuation routes should make possible a quick and safe exit outside the building or safer area or adjacent fire zone. To determine proper width, number of passages, exits and evacuation routes of buildings in which, according to destination and way of planning, there is no maximum number of users, there is obligation to accept 30 m² per person for storage buildings. For safe evacuation it is an obligation to:

- provide proper number and width of emergency exits,

- provide proper length, width and height of passages and evacuation accesses,
- provide smoke control of evacuation routes,
- provide well designed emergency lighting system,
- provide possibility of emergency fire alarm system.

The new thing is regulation for protection of mass events which can be an enormous danger of human life. As mentioned before all national regulations and standards are harmonized with European Union requirements.

Also there is an obligation for buildings including fire zone for more than 50 persons that the owner or manager of such buildings should provide and lead practical exercises including emergency evacuation once every two years. He should also notify the Provincial Commander of the State Fire Service of the time of such exercises one week before.

The State Fire Service has just introduced the new fire equipment according to European Union requirements. It includes especially:

- Firefighting and rescue vehicles.
- Overpressure breathing apparatuses.
- Helmets.
- Protective suits.
- Thermal imaging cameras.
- Positive pressure portable ventilators.

The medical rescue within the State Fire Service: Every action of the State Fire Service should offer the possibility of providing the listed life-saving and medical rescue procedures. Polish firefighters are to be trained, equipped, authorized and obliged in order to perform:

- Cleaning and maintaining airways.
- Oxygenation and controlled ventilation with 100% oxygen.
- Chest compressions according to CPR standards.
- Stabilization of proven or suspected fractures, sprains and luxations.
- Wound dressings.
- Initial antishock procedures.
- Cooling the burns.
- Providing thermal comfort.
- Psychological support that should be followed/confirmed by appropriate documentation.

The past fires gave us a big experience, to improve shortcomings to better protect people. From these lessons learnt we try to prevent such fires and to fight with them effectively.

Since 1995 we have in Poland the National Rescue and Firefighting System, whose aim is to integrate of all state services and non Governmental organizations for better protection and for better fight against fires and disasters.

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Fires in Greece: Two characteristic case studies

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1. Introduction

Wildland fires constitute one of the most severe environmental problems in Greece. The Mediterranean ecosystems of the country (coniferous forests of Aleppo and Brute pine, maquis of evergreen-sclerophyllous shrubs, phryganic xerophytic plant communities) form a continuous zone along the coast-line and up to an altitude of 600 m, which is strongly influenced by the Mediterranean-type climate with pronounced dry period during the summer months and mild winters. This situation, in combination with the mountainous terrain, creates very severe burning conditions and potentially extreme fire phenomena.

The Mediterranean areas of Greece are also under heavy population concentration because almost 75% of the total population lives in this zone, where touristic development takes place. Thus, they are constantly under serious anthropogenic disturbance through repeated cycles of fire, grazing and, eventually, pressure for land-use change. Almost 80% of the total number of fires in Greece occur in the Mediterranean zone and account for over 90% of the annual area burned.

During the past decade (1989-1998), there have been on the average 1,631 wildland fires per year, which burned an annual average of approximately 42,000 ha., which means 25.7 ha per fire. In the previous decade 1981-1990 Greece had a peak of 39.5 ha per fire, which was the biggest average area burned per fire among all EU countries (Spain 23.6, Portugal 15.3, Italy 19.7, France 7.6 ha). However, recently when Greece initiated the modernization of its fire fighting equipment by acquiring more and modern aircrafts, increasing the fire fighting personnel and the expenses for forest fire fighting and authorizing the Greek Fire Brigade responsible for this task with the assistance of the Forest Service, the picture had an improvement especially in the burned area. Thus during 2001 there were reported 2,658 fires with a burned area of 18,343 ha and for 2002, 1400 wildland fires with 4,337 ha burned area. It must be noticed that the number of burned area per fire depends mainly on the way of the “wildland fire” event definition in each country report.

Most fires occurred during the summer months (24% in August, 23% in September, 16% in July, 13% in October, 6% in June) during the midday hours (11.00-17.00 hrs)

In Greece also the statistics proved the characteristic distribution of large fires both in forest and building fires. Thus, only 4% of the total number of forest fires exceeded 1,000 ha in size, but they were responsible for more than 70% of the total burned area.

Concerning both building and forest fire statistics for the recent 3 years collected by Fire Brigade there are the following figures:

Number of building fires	2000: 9,201 fires, of which 5,880 occurred in residential premises. 2001: 8,798 fires, of which 5,712 occurred in residential premises. 2002: 7,783 fires, of which 4,987 occurred in residential premises.
Number of fatal fires	2000: 62 fatalities (1 fire fighter) 2001: 64 fatalities (1 fire fighter) 2002: 38 fatalities The above data refer to all fatalities regardless of type, building, area (forest-urban), etc.

2. Fire in Simonopetra Monastery of Mt Athos

2.1 History

The monastery of Simonopetra is one of the oldest high-rise buildings erected in the 13th century around a precipitous rock, close to the sea on the southwestern side of Mt Athos peninsula. Mt Athos is a 2033m high pyramid-shaped mountain, which lies at the southern point of the homonymous peninsula in Chalkidiki - a Greek area in the North - that stretches as a long spit of land into the sea.

The monastic community in Athos first appeared around the year 800 a.C. and the Byzantine Emperor Basil the first recognized Athos as a territory belonging exclusively to monks and hermits. In the beginning of the 13th century there were about 300 small and big monasteries all over the area of the so-called “Holy Mountain”. The area became a Pan-Orthodox spiritual centre with a great prestige and influence in Constantinople (Istanbul), whose renown had spread throughout the Byzantine Empire.

There are only 20 inhabited monasteries today in Mt Athos and the foundation of others is not permitted. Mt Athos even in the present period constitutes a unique living religious and cultural centre for the Orthodox Church. Access by the public to the area is restricted and according to an old byzantine tradition, women are not permitted access to the area. There are only forest roads or narrow footpaths and only one small port and some harbours, where small boats can approach. Structural damage and many cultural treasures losses have occurred in the past and recent years caused by fire.

2.2 Simonopetra monastery

The Simonopetra’s assemblage consists of three main wings. There are also other lesser buildings outside the monastery. Most of the external walls consist of wide stone masonry varying from 1 to 2m thick. Inside there is a variation of brickwork, masonry and light-weight traditional walls consisting mainly of stick and plaster (*bagdatotichi*). Concerning the floors and ceilings, there are timber floors, domes, Russian technique and concrete ceilings and floors. Timber roofing is covered by slate tiles.

2.3 Description of the fire

The main large fires in Simonopetra since its erection happened on:

- December 1580 (conflagration)
- June 1662
- May 1891 (conflagration)
- August 1990 (forest fire)

On 14 August 1990, one of the largest forest fires broke out on Mt Athos. Although many fire fighting forces took part in the operations of fire suppression (Forest firemen, Fire Brigade, Army, firetrucks, CL-125 aircrafts, helicopters, etc.), the fire burned for almost two weeks due to the strong winds blowing at that time. 2,230 hectares, of which 1,350 hectares of chestnut and oak trees and 880 hectares of scrubland had been burnt down.

The fire approached the monastery from the east on Monday the 20th of August. Although the monks with the assistance of the firemen turned it away, the fire returned back more threatening two days later and surrounded the monastery. Dry evergreen oaks and bay trees on the south in the root of the rock were ignited, and a turbulence of flying brands because

the very strong wind attacked the southeast side of the buildings. Some old wooden balconies were pulled out for replacement at that time. The fire spread inside the building through old timber beams and window frames and through the holes and the cavities of the external walls. The monks had then the idea to cut the burnt timber building elements in order to avoid the development of fire into the building. At the same time, they used the existing hose reel system to extinguish the fire. The self-denial of the monks with the assistance of the firemen saved the monastery from a new conflagration almost one century after the last one (1891).

The fire caused serious damage to the land property and the watering and irrigation systems of Simonopetra, ruined nine outside buildings and seriously threatened the main complex of the monastery.

2.4 Fire design

After the fire, a proposal of a new modern fire design was drafted. Although Simonopetra is a high rise building, it does not belong to the high hazard category. Weak points in the structure have been identified (cavities, timber elements, etc.) and available fire protective measures (fire doors, improvement of compartmentation, protected staircases, sprinklers and detectors, improvement of the hose reel system, etc.) were proposed.

In that proposal the importance of Prevention was emphasized. Fire Brigade access time in the area of Mt Athos is usually very long because the special conditions of the case. Prevention of fire means among others, restriction of combustible materials and smoking as well as safe use of energy.

A proper Fire Safety Management was also proposed, which includes the establishment of a permanent Fire safety Group consisting of 6-7 monks with adequate training in fire fighting and looking after the maintenance of fire safety systems. It also includes the training of all monks for the case of fire and perhaps other case (e.g. earthquake) emergency. On the other hand, a Fire Safety Manual was proposed containing the proper actions to be taken every day, month and year for maintenance and in the case of fire (salvage operation, isolation of valuable contents, etc.).

3. The conflagration of two large department stores in the centre of Athens [3]

On 19 December 1980, at almost 03.00 hrs, the Athens Fire Brigade received two telephone calls within 5 minutes difference, concerning two large fires that occurred simultaneously in two large multi-storey department stores, far from each other, in the centre of Athens. The real causes of those fires have not been discovered up to now, although there was significant evidence that both were due to arson.

3.1 The stores

MINION, the name of the first department store, is a complex consisting of five multi-storey buildings, ranging from seven to eleven storeys, which occupy a building block by four streets. It covers a total gross area of approximately 2,270 m². The five buildings were designed as office occupancy and nearly at 1970 they were unified and used together as a big department store named "Minion". Much alteration took place for this change of use. The framework of all 5 buildings was reinforced concrete. The external envelope was mostly brickwork and, to lesser extent, aluminium panels.

KATRANTZOS, the name of the second one, was a smaller building than Minion, consisting of a basement and nine storeys, comprising a plan area of 640 m² gross. It was erected in 1970, on a very sharp triangular-shaped site at the corner of two central main streets. Vertical compartmentation was abolished by fire-unprotected escalators. Aluminium panels on a steel frame covered all external walls. The framework was of reinforced concrete ribbed floors with expanded polystyrene formers left in position.

3.2 Description of the fires

Katrantzios

Fire started on the 7th floor and spread very rapidly all over the building due the absence of compartmentation and the lack of any active measures. The lift shaft and unprotected escalator behaved as a flue for the spread of fire. The exposed expanded polystyrene on the ceilings soon became involved and fell down, spreading the flames to the lower floors. The effect of this was an increase in the fire load and fire severity. The design of the external elevation with aluminium panels and only a small number of windows resulted to the confinement of the fire inside the building during at least the first 15-25 minutes with a rapid increase of the temperature. The maximum temperature estimated was not higher than 1000-1100 °C. The Fire Brigade could only fight the spread of fire to the adjacent buildings.

Minion

The fire started on the 5th floor and had the same rapid spread caused by the lack of compartmentation as escalators, staircases and lift shafts were unprotected. When the Fire Brigade arrived, the 3rd and 4th floors were involved in fire and the main fire fighting objectives were limited to protect its spread to the basement, where the oil tanks for the central heating and air conditioning were located, and to prevent the adjacent buildings. The probable temperature curve had the same shape as in Katrantzos, but with gradual build-up to high temperatures because there was normal ventilation through the windows.

A detailed description of the assessment of damages and the mechanism of the partial collapse of Katrantzos building is given in [3]. We will refer here only on the conclusions of this disaster.

3.3 Conclusions and lessons learnt

The Building Regulations and Design Codes of most countries make no provision for any special calculation of building assemblies in case of fire. They include only fire resistance requirements of individual structural elements, as well as calculations for small temperature differences, i.e. 20 °C, of composite load-bearing elements, such as frames. This is due to the beneficial influence of structural components interactions in a composite construction which, in addition to the favourable properties of concrete, makes the collapse of a concrete building in a case of a fire very rare phenomenon.

The “Katrantzios” store’s disaster was an exception which should lead to greater attention in the design of special or of peculiar shape structures. The main reason that “Minion” did not collapse was due to the close spacing of columns and the successful interaction between different structural elements.

The rapid fire spread in both cases was caused by the lack of compartmentation due to unenclosed escalators, staircases and lift shafts. The presence of expanded polystyrene formers in the ribbed slabs affected the rapid spread and the high severity of the fire. The

“Minion” fire highlighted the need to take precautions when a building occupancy changes and serious construction alterations are made. In those cases of the absence of compartmentation and open communication between floors the installation of a properly designed automatic sprinkler system should have been given serious consideration.

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The P.D.I. major industrial fire at Nicosia, Cyprus

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1. Description of the event and consequences

1.1 Location

The fire took place on 25 April 1999 at Pittas Diaries Industries (P.D.I.), Nicosia, Cyprus. The dimension of the factory was 120m x 110m x 10m. The factory has three different sections: The main factory, the offices and finally the engineering department with the ammonia depots. The three buildings are separated from each other.

The main factory

The main factory consisted of iron beam frames, sandwich panels for walls and compartmentation into two main parts by 1-hour fire resistant wall and doors. Secondary internal compartmentation was achieved using sandwich panels (5 cm wide for the ceiling and 10 cm or 20 cm for walls). All iron columns were covered with concrete up to 6 m high. The northern and southern walls were made of reinforced concrete 12.5 cm wide and 2.5 m high. Polyurethane sheets were widely used for temperature control. Compartmentation was achieved up to 3 or 5 m with vertical sandwich panels. Sandwich panels were used to cover the ceiling. Compartmentation did not reach the roof and was stretching only up to a height of maximum 5 m. The area above the 5-m height and up to the ceiling was not compartmented and formed a unified area (Fig. 1).

The floor was made of reinforced concrete but much of it was painted with epoxic material of 9-12 mm of thickness made of polyurethane.



Figure 1. A view of the factory from inside. At the back it is visible a compartmentation which does not extent all the way to the roof!

The main factory had two main compartments and a number of smaller freezer rooms and other specialised rooms used for the preparation, packaging and processing of the dairy products. The main factory was sealed from outside temperature and environment for hygiene purposes and temperature control. Air was filtered before intake through three different filters.

The offices

The offices are a separate building adjacent to the main factory. It is a three-storey building, 30m x 30m. Their construction was made of reinforced concrete and brick. The fire did not expand to this building, even though smoke entered some of the offices damaging wall paint and some equipment such as computers, etc.

The engineering department

Ammonia and diesel depots were housed in a third building 8.5 m away from the southern part of the main building. It was constructed of reinforced concrete and brick. This department is consisted of the boiler room, the ammonia depots, the generator, the control room and the electricity sub station. Outside of this building there are diesel oil depots in brick enclosures. This building connects with the main factory. Fortunately, at the time of fire the wind was blowing the flames and smoke to the opposite direction and only minor damages were caused to the engineering building, which suffered most of its damages from radiation heat. The main efforts of the Fire Service were to prevent the fire from spreading to this building knowing that if ammonia was engaged in the fire toxic fumes would be released.

1.2 Consequences

There were no fatalities. 5 fire fighters were lightly injured and sick from smoke inhalation; also 10 civilians were hospitalised for breathing problems.

The P.D.I. factory (12,500 m² destroyed) estimated damages amounted to 15 million CYP (about € 25 million) (Fig. 2).

P.D.I. was using one-fourth of the country's milk production (45 Tons of milk on a daily basis) and half of the country's sheep and goat milk product. P.D.I. was the biggest dairy product producer with exports to the Middle East, Europe and America.

Due to the closure of the P.D.I. factory, the milk production was diverted to other manufacturers of dairy products and the old P.D.I. factory, which was closed down only recently before the fire, was re-opened to satisfy the milk product. The fire hit hard the country's dairy industry because the P.D.I. factory, which was about to operate fully, was built to the latest international standards and its products were exported to many countries. In addition, the P.D.I. factory was producing a number of patented products, which could not produce now and for the next period of time.

The biggest problem was with the P.D.I. local and foreign competitors who were now called to fill the gap in the market created by the absence of the P.D.I. products. A long and continuous absence of P.D.I. products in the short run from the market due to its inability to produce, might lead to a devastating exclusion of P.D.I. products in the long run due to the strengthening of its competitors in the market.

The possibility of a total economic destruction of P.D.I. due to the fire was a real possibility with direct implications to the whole dairy industry of Cyprus and to the country's economy as well. Immediate measures were needed to save P.D.I. and for its recovery and also for the support of the milk producers.



Figure 2. P.D.I. factory after the fire. Partial collapse

2. Prevention, protection and safety measures

On 28 November 1995 the Fire Prevention Office of the Cyprus Fire Service studied the plans of the new industry and made a number of suggestions concerning the fire prevention and protection of the industry.

The major suggestions concerning fire safety called for:

- Compartmentation of the factory into the following:
 - The main factory to be separated into two main compartments (the Process unit and Store area) using one hour fire resistant materials (masonry wall).
 - The offices
 - Ammonia depots
 - Engineering department
- The installation of fire detection system.
- The installation of fire fighting system.
- The complete isolation of the engineering department from the main factory.
- The complete isolation of the ammonia depots from the main factory.

3. Preparedness plans and actions

Due to the fact that the factory was not fully operational yet and that it had just begun its limited operation no specific emergency plan or organisation of intervention teams were present neither any fire fighting and evacuation exercises were performed.

4. Response/intervention actions

- Date and time of event: 25/4/99 08.25
- Time of fire service arrival to the scene: 25/4/99 08.33
- Date and time of fire under control: 25/4/99 11.38
- Date and time of last vehicle to return: 27/4/99 13.50

The fire vehicles found it very difficult to approach the burning factory because of nearby road construction affecting the road to the factory. Also, the smoke was covering the nearby road to the factory making driving very difficult. Upon arrival, the fire fighters began fire suppression through the wall openings created by the immense heat from the fire inside the factory. Simultaneously, the fire officers gave instructions to prevent the fire from spreading to the other two buildings (the office department and the engineering department with the ammonia depot). Entry into the burning factory was prohibited in the early stages because of immense heat, the danger from falling debris and finally from the danger of entrapment. Eventually, the factory collapsed in the next hours and the prohibition of allowing fire fighters to enter it prevented serious injuries and possible deaths. Overall, 10 fire vehicles were used and 67 fire fighters. In addition, 5 retain fire fighters were called to assist in the initial efforts.

4.1 Fire cause

A detailed fire cause investigation was carried out beginning the next day. The main findings were as follows:

- The on duty security officer first noted the fire.
- He alerted the local fire station on 25 April 1999 at 08:25 hrs. The first fire engines arrived at 08:31 hrs but did not start fire fighting immediately as they could not approach.
- The firemen reported encountering a fire spread throughout the factory and thick black smoke covering the entrance to the factory making visibility very difficult and approaching the burning factory impossible. Approach to the factory was achieved by cutting the wire fence at an area opposite the direction of the smoke and with the help of a nearby private digger, which made a ramp for the fire engines to approach the factory.
- All of the factory entrances were found shut and locked.
- The fire resulted in the complete destruction of the main factory with all of its contents in machinery, products and other premises.
- The Fire Service managed to save the Offices building and the Engineering Department with the Ammonia and diesel oil depots.
- On 24 April 1999, one day before the fire, there were still different structural operations under way. On 24 April 1999 between 07:00 and 16:00 hours there was welding work carried out in a specific area. After work was over, all of the welding machines were transferred to the storeroom except of one, which was of heavy duty and of special type. This Argon type-welding machine needed 415 Volts to operate and was used for stainless steel welding. It was reported that on several occasions and always during the operation of this specific machine the electricity circuits would shut down, as safety fuses could not carry this load of electricity. This specific welding machine needed 25 – 50 Amperes to operate, but during the investigation it was found connected to a 16-Ampere socket. It was also reported that the electric cables of this specific machine would warm up during operation especially when they were not straightened. During

the day prior to the fire, this welding machine was used extensively and was moved around using the same electric wall plug.

- The floor of the area where the welding work was being carried out and much of the remaining factory was covered with an epoxic material which was later proved to be flammable in very high temperatures.
- As regards to the fire detection system, it was reported that a system of the latest technology was fully installed by July 1998 (9 months prior to the fire), and in September 1998 (8 months prior to the fire) this was tested and the system programmed. The specific fire detection system was capable of detecting smoke and after detection it was programmed to give an alarm onto the main control panel, print the number of the specific detector which first detected the fire and make prerecorded phone calls. This detection system was never put to use. After the fire and during the investigation it was noted that the fire detection system was not operating. The batteries were not connected and the switchboard to the OFF position. Many of the individual smoke detectors still carried the manufacturers cover. The explanation given was that because there was still work carried out in the factory and this was occasionally setting the smoke alarm on, it was decided to set it in the OFF position until work was fully finished.
- From the fire spread and different other information gathered at the site of the fire, the fire investigation concluded that the fire began from the room where the argon-welding machine was in. It was also concluded that the fire was in a slow burning situation for quite some time.
- The fire resulted in the complete destruction of the factory (Fig. 3). Due to the extreme temperatures during the fire, much of the material, which could be used as evidence in the fire investigation, were completely destroyed. Nonetheless, the electric wire connecting the welding machine to the electric socket was found connected but it could not be established for certain if the socket or the welding machine were on the ON or OFF position. It was, however, established that the electric wire (found in circular piling) had clear signs of shorting.
- Having in mind all of the information gathered during the fire investigation, the possibility of the fire starting as a result of an electric shorting of the wire of the welding machine is a very high possibility.
- During the fire investigation no evidence was found that could lead to the possibility of the fire having been set intentionally.



Figure 3. View of the factory after the fire. Next to the fire fighter the argon welding machine

5. Lessons learnt

5.1 Fire fighting

- The initial approach problems made it clear that in the future no public work operations should be conducted that would hinder the approach of fire trucks to any premises of high fire risk or that other sufficient ways would be secured.
- The use of breathing apparatus should be a must by all fire personnel during fire fighting of similar fires.
- The absence of active fire fighting systems was noted and their presence might have resulted in an early automatic fire fighting and saving of the factory.

5.2 Fire prevention

- Fire detection systems should be in an operational position as soon as they are installed.
- Sandwich panels proved unreliable in very high temperatures adding to some extent in the fire spread.
- It proved that with good compartmentation methods the fire spread can be controlled and prevented.
- The Fire Service's suggestions to completely isolate the engineering department with the Ammonia and diesel depots from the main factory proved correct as this measure kept this compound away from the fire. A possible fire spread to this compound would have resulted in a toxic cloud with all of the negative consequences.

5.3 Fire plan

- There was no fire plan prepared by and for the factory's personnel.
- It is now the law that all factories in Cyprus have their own fire plan, which is submitted to the authorities. Also, it is demanded that all personnel involved perform regular fire drills in the fire plan and also evacuation drills.

5.4 Safety at work

- It was noted that not all safety rules and procedures were carried out during work.
- Stricter rules, regulations and procedures have been implemented since then.

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Damage and hazards of smoke. The prevention against contamination by smoke – a tactical sight

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1. Our mission – another sight

Fire-fighters all over the world have the mission to fight fires, rescue people and animals and prevent huge damage to property. All these jobs would be managed from most fire brigades. At the result there should be no difference between a professional-or volunteer-fire-brigade. But, are we all doing the right job? Is it enough to extinguish a fire without the sight of developing damage to property caused the by intervention of the fire-brigade? We should start to recognise the problems of the affected persons or business that can be caused by our action.

The insurance companies and the media measure the action of the fire-brigade at the loss of life and monetary damage that is caused by fire. Is this a quality criteria about the work of a fire-brigade or the necessity/implement of building regulations? A detailed statement would be the determination of the saved value by the fire-brigade and the prevention from more damage through technical and building constructions. We all know this is not that easy, but the thought "what kind of damage and which damage could be avoided" should be our theme. This theme and the tension between fire prevention and fire fighting will be explained with the help of some examples. Dr. Markus Pulm has published his thoughts and ideas on this theme in his book "Falsche Taktik – große Schäden". The following incidents with the conclusions are a result of the change of our tactics through these new ideas.

2. Fire prevention

The building regulations and codes should be taken into account before a building gets erected. Usually the fire brigade gets involved before and during the building design and construction.

Here it is possible to make influence as an adviser and inspector. Next to the conventional and passive fire protection more building complexes are getting erected with technical and organisational fire protection.

The main focus of passive fire protection is the formation of firewalls and smoke control units. The use and installation of walls, ceilings and doors with quality standards insure the space-enclosing and function of these fire- and smoke units. Are these constructed considering the Regulations, we can presume that fire and smoke will be held back in these units for a determined time. These doors and walls are required from the fire prevention officers in context with the building regulations and the relevant fire tactic.

Most dwelling buildings built in Germany are erected following the conventional fire protection codes. Fire safety engineering does not play a big role designing dwelling houses, but it is getting more important in industrial, office and multistorey buildings.

3. Fire fighting

The usual tactic to fight a fire will be showed by the following hypothetical example:

3.1 Standard operating – Fire in an industrial building

In a one-storey industrial building a fire starts out of the operating hours. The fire is visible from a window on the rear side. A table is burning in an office. The office is fire integrity separated from the production. There are no persons in danger or injured.

The fire-brigade arrives at the scene few minutes after receiving the emergency call. The brigade starts action after a short reconnaissance. The first troop takes his equipment, hose and walks with breathing apparatus (BA) across the production hall towards the fire location. This is the usual and common way.

Till this moment the fire and smoke was limited in the office room, but now the fire door gets opened .

The fire is extinguished in a very short time, but as the door has been opened smoke entered the production hall and the mechanical plant was contaminated. This contamination led to a huge damage, because the company was not able to restart production for a longer period.

The statistical information from insurance companies in the United States has determined that out of the firms which had a major incident of fire 23 % get on the market full operating, 6% are sold or merged, 28 % get off the market within three years and 43 % vanish from the scene.

The local press would praise the fast success of the fire-brigade and complain about the huge loss of property.

Most fire-fighters will maintain that this example is overdrawn, but how often did the action cause a higher damage as a reason of convenience, thoughtlessness or even while “we are doing it always this way”?

Which way or tactic is the best or the right one? There’s no universal solution. But we can try one or more alternative methods to do a good job.

3.2 The alternative

The reconnaissance is one of the most important premises for a successful result. The commander needs more time to localise the centres of danger. In our previous example the commander had to survey the scene more intensively to analyse what kind and how big the damage is at time of arrival and which course the damage is expected to take without taking action. The expected damage can be divided in expanding damage per time and damage expected per action by the fire service. In this case the quick strike through the production was not necessary. No human or animals have been threatened and the office inventory was already destroyed or contaminated by smoke. So here there was no increasing loss by damage in this unit. The fire wall and door was intact and enclosed.

In this case the fire service had the time to choose a longer way. The attack over the window at the backside of the building would have needed only a few more minutes and nobody had to enter the office from inside the building. It is possible to extinguish this fire from outside through the window. We can leave the fire door closed and no smoke nor heat could harm property behind the fire wall.

We can transfer this example to an incident in dwelling houses, one- or multi-storey buildings, even in high rise buildings. Our obsession has to be – look for a alternative route to fight the fire without an increasing damage through smoke and the action of the fire-brigade!

Additional to the right decision of the route to fight the fire is to control the smoke. In our example, the smoke and heat could escape directly through the window. What happens if this is not possible? In this case the fire fighters have to look for an alternative route to evacuate the smoke, always weighing the consequences of what damage already happened and what damage is tolerable. This might not be the easiest way, but it is worth thinking about it.

Depending on the kind and use of buildings it could be meaningful to “sacrifice” undamaged rooms or units to protect an area with valuable property.

Our example gives advice on how to by-pass damage to property. What about incidents with injured and trapped persons?

Using an access without considering the consequences can bring persons in safe areas in danger. How often is the only stairway, corridor or gallery useless because these units are penetrated by smoke? The reason here for is in most cases a fast attack through these areas without arrangements against spreading smoke, like thermal- or positive pressure ventilation. Or another reason is – the fire fighters have not looked for another alternative access and route. Choosing an alternative access, for example a window, door or a route through adjoining rooms could solve this problem.

Examples from real incidents demonstrate what can happen if stairways or corridors cannot be passed. The human behaviour and reaction at this point cannot be estimated, and the result is often panic. In many cases the “saved persons” got in danger because the fire service did not choose the right access or made the wrong decision. Their action led to more smoke propagation and prohibited the use of stairways and emergency exits.

Looking for alternative access routes is not possible at incidents when persons are missed, trapped or it is not sure that somebody is missing. Then of course our action has to be forced to a quick and successful life-saving - without compromises. But in many cases there are no persons involved.

4. Incidents

The alternatives will be described in the following two incidents in Karlsruhe.

4.1 Fire in a basement garage

The garage was built 1995 as a basement garage and is part of a multi-storey dwelling house (Fig. 1). The garage has 1,400 m² ground area with 88 parking spaces. The parking spaces are constructed as a hydraulic double park system. The garage is natural ventilated. The car access occurs over a ramp through a electrical gate at the south side of the building. The access from the garage to the houses is possible through fire doors and the corridors of the cellar to the main stairways. There are two fire doors as a lock between every access from the garage to the cellar corridors. There are only two ways to enter the garage from outside, not using the house entrances: the ramp and the bicycle cellar at the southwest side of the garage. The garage is built in accordance to the building codes for garages and was in very good technical shape. Conforming to the building regulations the garage is fire integrity separated from the dwelling house and rooms which are not associated to the garage, with fire resistant walls and ceilings and fire doors (30 minutes resistance). The emergency exits were marked with illuminated signs.

A car fire started on the upper parking space No. 90. The reason of ignition could not be determined (Fig. 2 and 3). The residents realised the smell of smoke at 00.27 hrs.



Figure 1. View from the southwest direction to the garage and dwelling house.
The garage ramp is located on the left side



Figure 2. The parking space, where the fire started



Figure 3. The burning source, above the chipping concrete

At this alert stage the professional fire brigade turned out with two fire engines, one turntable ladder and the operation officer and a fire engine with volunteer fire fighters. The fire fighters where able to smell the smoke during the run at one kilometre distance before arrival. The first fire engine reached the scene six minutes after the emergency call. Thick black smoke was leaking through the gate. It was a warm summer night and most residents were sleeping with open windows. That is why the fire was realised at an early stage. But next to the positive reaction (the early emergency call), many residents realised the smoke and got upset. They deserted their apartments and walked on the street.

In the short time of the blaze the electric power supply of the garage had a breakdown. It was not possible to enter the garage over the ramp because the gate could not get opened manually. The fire was visible through an air shaft at the rear side of the building. The vegetation around this shaft got ignited. The fire fighters realised that the location of the blaze was at the opposite side of the ramp. As possible access route there was only one of the stairways and cellar corridors of the apartment houses or the way through the bicycle cellar.

At this time the situation was not getting worse inside of the garage. There was no higher loss of property expected because the whole garage was contaminated with smoke. There was no chance to save property and after an intense reconnaissance the commander could be sure that nobody was inside the garage. Even if the car was still burning, the situation was only terminated to the enclosed garage. From this reasons the commander decided the longer way, the access through the bicycle cellar (Fig. 4).

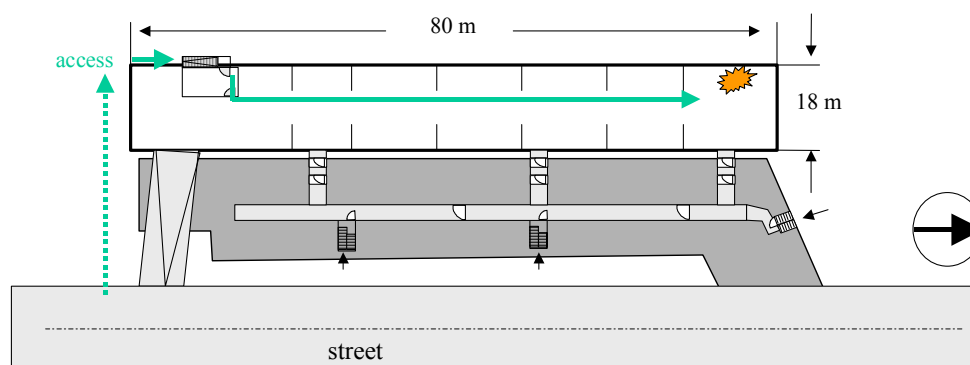


Figure 4. Plan of the site

The attack was started with two troops with breathing apparatus and a thermal imaging camera and one hose with a jet-spray branch pipe. One rescue troop with thermal imaging camera stood stand-by over the whole time.

The troops had to move nearly 80 m to get to the source of fire. This was a long and time consuming way (but this was accepted), looking forwards to keep the damage low and even the fire was still burning (the situation was stable).

During the action a third fire engine and a unit with breathing apparatus completed the fire fighters on the scene. The fire was completely extinguished one hour after arrival.

Positive pressure vents where used to clear the garage from smoke. At this time the decision of taking the access from outside without a smoke contamination of the stairways proved to be the right way. It was very difficult to build up a positive air cushion from the stairways towards the garage. A reason here for this was the construction of the basement corridors with single compartments and a south wind. Different constellations with two and three



Figure 5. Firedoor opposite to the burning source. The illuminated Emergency sign still works (the photograph was taken the day after the incident). There is a good view of the damage by smoke

vents in serial and parallel positions have been tried out, and the result was not satisfactory. Even when the fire was extinguished, some smoke could enter by this way the stairway, but there was no damage caused. During the action all fire doors were closed and there was no smoke in the not affected building areas.

This experience proved the decision of the commander, to use the alternative access, was right. An attack through the stairways would have caused more damage by the entering smoke through the garage doors to property and eventuality to persons.

Many residents stayed during the incident in front of their houses. They were upset and nervous. The fire fighters had to support them and calm them down. A smoke extension through the stairways may have threatened the other residents in their apartments. A panic reaction would have been possible.

Interesting to report is that the illuminated emergency exit signs were still running hours after the incident (Fig. 5).

The fire caused a € 120,000 damage in the garage and € 50,000 inventory damage (i.e. damaged cars).

4.2 Fire in penthouse

A fire started in a penthouse apartment in a four-storey dwelling house at around 14.00 hrs (Fig. 6). The apartment has a living room with open kitchen, a separated bedroom and bath. The access to the apartment is ensured over a inner stairway. This stairway is terminated by smoke control doors to the corridors. There is a fume extraction cupola at the highest point of the stairway.

Two engines and one turntable ladder from the volunteer fire brigade and one fire engine and one operation officer were sent to the incident. The volunteer forces arrived seven minutes after the emergency call. They started an attack over the stairways and released the fume extraction cupola. The cupola failed.

The caretaker of the building complex informed the commander that the apartment was getting renovated and that the new lodger had left the apartment half an hour before the fire started. There were no persons in the apartment.

With this information (the failed fume extraction cupola in a inner stairway and no expected hazard to persons), the commander decided an attack with a portable ladder from outside. He stopped the attack at the stairways and sent a second troop with BA and a branch pipe to the roof terrace (Fig. 7). The first troop stood stand-by with his full equipment in front of the door in the inner corridor.



Figure 6. The location – street view. The access to the entrance is located at the left side of the building. There is a footpath which leads to the entrance at the rear side



Figure 7. View from the rear side. The penthouse is visible at the right

At the time the hose and door opening tools were built and reached up, the troop on the terrace could inspect the apartment from outside through the windows, because every room was visible from the roof terrace. After this it was clear that nobody was inside the apartment.

This troop was even able to observe the fire in the kitchen. 17 minutes after arrival, the fire was extinguished.

The fire was realised early from the caretaker. That is why the fire had no time to expand and the damage was low (Fig. 8). There was only a light smoke damage around the kitchen and living room. No smoke entered the stairway. The damage of inventory and costs for the renovation was € 10,000. No persons were injured.

In this incident the longer and time-consuming route was chosen. There was no increasing damage and the fire was visible controlled from outside. The commander was on a safety side: at a sudden change of the situation the troop in front of the apartment door would have been able to take action with a fast response. But in this case the smoke would have contaminated the stairways and corridor through the opened smoke control door. This door lost its function because the hose laid between the door and the door frame.

Reviewing this incident all fire fighters verified that the access from outside had been the best. Even the first troop, who waited in front of the apartment door, confirmed this. They only had problems about waiting in front of a door when there was a fire behind. The fire fighters have to be disciplined in this case.

The reason of ignition was a plastic tool box laid on a electric stove. The whole apartment was cut of electricity for a long time, because nobody lived in it. The new lodger had this information and did not take account of the switches of the stove (Fig. 9). During his absence the power supply was put on from the power service. The stove switch was on and the plate set the plastic tool box in fire.



Figure 8. Little damage in the kitchen



Figure 9. Recognise the switch...

5. Main lessons learnt

- Looking back to the beginnings of this tactic, it was a long way to get these new ideas in our minds. There is a permanent improvement and training necessary to keep this alive. We have to reflect our action.
- To by-pass damage through our action, we should look over our standard tactics. In consideration to the possible huge loss of property with all the consequences for the affected people we should be more sensible. This is not a revolutionary thought but it is worth thinking about it.
- By the exchange of ideas with other fire-brigades in Europe, we noticed that it is time for a change.
- Not only a change of the tactic can solve all these problems; we have to think about building solutions.
- These days experts still discuss the best position of wall hydrants and rising mains. Positioning these fittings towards the entrances and corridors behind of fire doors has more advantages than disadvantages. This simple positioning would solve the problem that fire doors and smoke control doors will lose their function through fire hoses or wedges when the fire fighters do their job. The loss of the function and space-enclosing of these important doors is one of the main problems. We have to look for technical solutions and the support with an adaptation of building regulations and codes. There are some proposed and similar solutions to this problem on ships. Here some flaps are built next to the doors to be opened for cables and delivery hoses. These solutions have to be proved and tested if they can be used for buildings.
- Furthermore, we have to look for alternative ways to ventilate smoke contaminated areas and rooms. The common way is to direct the smoke through stairways and corridors. But these are the emergency routes and exits, and in the main cases the only access for the fire service.
- A smoke contamination leads in the foreground to more damage but it prevents the exit to persons and residents who need to be rescued at a later time and in some cases even to fire fighters.

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The 21 April 2002 fire at a 10-storey apartment block in Bucharest, Romania

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1. Description of the event and consequences

A devastating fire burst out few minutes before noon of the penultimate Sunday of April 2002, in a 10-storey apartment block at the Drumul Taberei area in Bucharest capital (see Fig. 1). The fire destroyed integrally 32 apartments on two staircases and other 45 were partially damaged in just few tenths of minutes, leaving on street 160 people, of which just one apartment was insured. The fire was ignited from a warehouse of the textile firm “Multi Core Trading S.A”, having as shareholders five citizens from Cyprus, located at the basement of the block. The military fire fighters arrived at the disaster scene with 9 fire-fighters tankers and extinguished the fire on the block after one hour and a half. Because of the strong wind, the fire was extended with high rapidity on the front of the block, severely affecting the apartments of the first four storeys and breaking the windows of the remaining ones up to the tenth storey.



Figure 1. The operative action of the fire-fighters at the affected façade of the 10-storey block

As a result of the fire five persons were intoxicated, being interned at the hospital requesting medical assistance. Also the fire seized two minivans parked in the front of the block, which exploded causing panic in the neighbourhood. The building specialists arrived afterwards at the fire scene affirmed that the resistance structure of the block was unaffected, but the entire façade needed to be fully repaired.

As a result of some complains of the inhabitants, the same firm was contravention billed twice in the past (for about € 640 and € 1000 respectively) by the “Building Discipline office” from the local City Hall of the 6th sector, due to the illegal compartmentation made inside their office located at the basement of the block, which could affect the resistance structure of the block, and because of the construction of a metallic cover in the front of the block, which posed a serious fire risk because of the plastic cover (see Fig. 2).



Figure 2. Detail of the illegal metallic cover of the commercial space of the firm responsible for the disaster

The Fire-fighter Report of the disaster mentioned three possible causes which could ignite the fire: an electrical device malfunctioned or improvised, a thrown lighted cigarette by a firm's employee or an inhabitant, or an open fire, because many witnesses stated that textile wastes were burnt periodically in the warehouse of the firm. Another fact drawn in attention of the public opinion by mass media was that the firm “Multi Core Trading S.A” insured the space firm by almost USD 1.7 million, representing it as follows: the space firm with USD 200,000, the merchandise with USD 600,000, and for any eventual damages an insurance of about USD 900,000. According to mass media also the insurance retrieval from the insurance company could be a reason for self-ignition of the fire in the firm. Anyway the responsibility for establishing the real causes of the fires is generally a task of the Police investigation.

Because all 160 people affected did not have any insurance, excepting one family, the Government took the initiative and covered integrally the cost of the block renovation, which was finished in less than one week, in order to permit to the affected inhabitants to move back. The total sum granted from the State Budget was about € 240,000, of which about € 130,000 from the Government was for the whole renovation of the block façade and the affected apartments, and about € 110,000 from the local City Hall of the 6th sector was the total compensation of the inhabitants for domestic objects to replace the damaged ones.

2. Prevention, protection and safety measures

Generally, the activity of fire prevention is undertaken in the frame of the whole technical and organisational measures, also by specific activities, planned and realised at the local and national level, according to the law, in order to assure the identification, evaluation, control and mitigation of the risk of fires in buildings. The existing legislation in the frame of the fire protection of buildings, constructions and installations, through the general and specific norms, requests building codes, which have to be respected during design, construction and also for their exploitation.

The socio-economic development programmes drawn up at national level, compulsory included the specific prevention measures in case of transformation of normal fires (including fires in buildings) in mass fires. The responsibility of this task belongs to the central or local public authority and to the technical-administrative leading staff of the economical units and the public institutions.

It should be mentioned that the organisation, coordination and control of the measures and actions for response in case of mass fire are undertaken at the national level by the Central Commission for mass fires, organised through the Ministry of Administration and Interior.

The Governmental Decision (HG no. 1088/30 .11.2000 [1]) regarding the Approval of the “Regulation for defence against the mass fires” was elaborated and adopted. This deals also with the situation of public emergency generated by the fires in buildings, among other types of fires (generated by dangerous combustible substances, etc.). It has to be mentioned that in Romania, the Governmental Ordinance no. 60/1997, regarding the defence against the fires, approved by the Law no. 212/1997, regulates the activity for prevention and extinguishing of the fire, among others existing regulations [2,3,4].

Periodically the Commissions for defence against the disasters organised and undertook applied exercises in order to verify the preparedness of the population and intervention forces. The verification of the functioning of the alerting-warning system, and also the equipment and the materials for intervention, was done at the established terms through the normative acts in force.

Regarding the circumstances of producing the fire at the block at Drumul Taberei area, the local City Hall (of the 6th Sector) applied in the past 7 contravention penalties to the Cypriot firm owning the commercial space, as a result of the reclamation of the inhabitants. However, the firm rejected the penalties and attacked in court the local City Hall of the 6th Sector, which, in their opinion, had no authority to evacuate them from the block basement (it has to be specified that the building authorisation for the firm place was obtained from the Capital City Hall, in April 2000, but without including the metallic cover, with plastic roof, which also contributed at the ignition of the façade of the block during the fire disaster).

2.1 Lessons learnt

- The continuously increasing contribution of the private sector to the whole volume of the economical activity, through privatisation of the economical societies, or starting new ones, will lead to a higher number of fire events in buildings from the total number of the fire-fighters interventions.
- Any building authorisation had to have as a legal base the approval of the fire-fighters inspectors.

3. Preparedness plans and actions

In Romania, for the important buildings, also for the municipalities, there are elaborated plans for intervention or operatives files, in which the main elements regarding the organisation and leading of the intervention in case of fires are included. These Plans are drawn up for counties and municipalities by the Commissions for defence against the disasters, constituted according to the Law of defence against the disasters, no. 124/1995, and for the economical agents and public institutions by the technical-administrative board, and are used as a base for undertaking the prevention measures, the preparedness, the immediate intervention and unitary leading of this.

It has to be specified that when drawing up or updating the defence plans the evaluation and establishing of the zones with risk for producing and propagation of mass fires in the inhabited areas are carried out. The levels of high or very high risk are distinctly marked on the map of the risk zones, annexed to the defence plans. The defence plans are revised any time if necessary as a result of the changes happened in the area/objectives that were drawn up for.

According to this Plan, in this kind of situations, the military fire-fighters take action, together with the units of the Police, gendarmerie, civil protection units, citizens, and medical personnel. It has to be noted that in Romania exist three types of fire-fighters intervention forces, as it follows:

- a) The Military Fire-Fighters are the public institution of national interest specialised in prevention and extinguishing the fires, having attribution for coordination, control and providing technical assistance. It belongs to the Ministry of Administration and Interior, having as operational forces 41 brigade/groups of military fire-fighters, including 41 bureaus for fire-prevention and 232 subunits of intervention, with an endowment of 1,652 fire-fighter trucks, dislocated in 196 localities, of which 39 in more developed rural areas.
- b) The public services of civilian fire-fighters consist of 1,836 services subordinated to the local authorities, with an endowment of 606 fire-fighter reservoir trucks and 814 engine-pumps. The public services of civilian fire-fighters activate 31,424 fire-fighters, of which 1,155 are professionals.
- c) The private fire-fighters services are constituted by 2,161 economical units, which have 660 fire-fighters cisterns, 3 trains, 5 extinguishing ships and 1,415 engine-pumps and activate 38,214 fire-fighters, of which 18,182 professionals.

Generally, for establishing the tactical conception for extinguishing a fire in a building, it is imposed the following:

- The analysis of the real situation, the knowledge of the zones affected by the fire, the structure of the combustible material, the extension limits where the fire will be spread,

the possibilities of taking over the control of these, the zones with the highest intensity of this and the necessary means for diminishing the potential of this;

- Taking into consideration the factors that favour the extension and the intensification of the fire, the exactly time of observation, the wind speed and direction.

3.1 Lessons learnt

- In order to have an efficient preparedness phase, the endowment with means and equipment of intervention has to be conceived into a unitary way.
- The existence of the electronic devices for alarming-signalization of the fires or smoke in the buildings can ensure an efficient preparedness phase of the fire fighters.

4. Response/intervention actions

Generally, the leading of the whole intervention operation in the situation of public emergency generated by the mass fires is taken by the authorities legally invested, which have attributions and responsibilities regarding the conception, planning, organisation and control in this field, respectively the prefects, majors and the technical-administrative boarding staff of the economical units and public institutions. The procedures for the propagation limitation, for the extinguishing and elimination of the consequences of mass fires, which can be produced also by fires in buildings, were established by the Regulations and the Instructions elaborated by the General Inspectorate of the Military Fire-fighters Corps.

The application of the defence operational measures against fires in buildings is realised into a unitary way on the basis of the operative plans for protection and intervention in case of disasters in the counties, localities and the economical sites, called defence plans.

Regarding the case from Drumul Taberei, immediately after the disaster took place, the Prefect of the capital accompanied by the local Major of the 6th Sector arrived at the affected block in order to lead the rehabilitation activities.

Following the disaster, an operative Commission was constituted at the Prefecture office by the Bucharest Prefect, Mr. Gabriel Oprea, at around 18.15 hrs, in order to solve the problems of the homeless persons. On the same day of the disaster, it was decided that the affected people would be hosted for the following days, until the repairing of the block, at the Sport Hall of the Auto High School located in the same Sector. Also the National Society of Red Cross sent emergency humanitarian aid consisting of blankets to the homeless people,. The Police and Gendarmeries units guarded the affected block during the following days, because many belongings of the inhabitants, which were saved from the fire, were deposited in the front of the building.

During the next day, the Prime Minister accompanied by the Ministry of Transportation and Public works visited the affected block. He decided that the repairing should be finished before Easter, just in one week, and that the money would be allocated by the Government from the emergency responds Fond.

Also the following days, the Government took the initiative for a Project of elaboration of a normative act for the Obligatory Insurance of the Houses against the natural disasters and fires. It is foreseen to enter in force in the near future the new law of Obligatory Assurance of the Houses and the population will have the obligation to insure their houses. In this way it will be solved the acute problem of indemnity for people affected by fires.

4.1 Lessons learnt

- In order to ensure the mitigation of the disaster effects during the response phase, it is necessary the endowment at the local level of the Commission for defence against the disasters from the inhabited areas with a special building fond, designed for natural calamities or man-made catastrophes, in order to assure the accommodation of the homeless people affected by the disaster.
- For minimising the pressure against the local community budget in case of fire, the existence of an insurance system for the houses and goods against the disasters, including fire, is very efficient because in the case of producing an incident with damages, the indemnity of the affected people will be automatically covered by the insurance companies, and the financially coverage of the response action will not be affected.

5. Dissemination of information to the public

In the case of a fire in a building, the informational-decisional system comprises the whole subsystems designed for detection, alarming, warning, notification, data transmission and processing, taking the decision of the factors involved in the defence actions against the fire and the transmission to the interested factors.

For ensuring the transmission of the updated information by the Commission for disaster defence were established in due time, through the defence Plans, the type of the networks, frequency and the telecommunications means which are used and where will be ensured a permanence activity. The transmission of the information is realised according to the scheme of the decisional-informational flow, approved through the Plan for defence against the disasters.

The principal scheme of the decisional-informational flow in case of a mass fire is presented in Fig. 3. In case of the buildings which do not belong to the category of the mass fires, the leading of the interventions is ensured by the Major of the locality (as President of the Local Commission Against the Disasters), by the commander of the military fire-fighter major unit or subunit, when the civilian fire-fighters service is overwhelmed and request the intervention of the military fire-fighters, or by the Prefect of the County, when more that two subunits of the military-fire fighters major unit are engaged (see Fig. 4).

The information of the decisional factors and the mass media regarding the situation on the fire scene, the evolution and the extinguishing of the fire, the negative effects produced and the measures taken was undertaken through the operative Reports.

The General Inspectorate of the Military Fire-Fighters manages the information at the national level, by specialised informational programs. The intervention statistics for fire fighting at the county level are made by the county fire-fighter brigade.

On the basis of the conclusions drawn out from the analysis of the intervention, the defence Commission made proposals for the measures to improve the activity of prevention and extinguish the fires in buildings.

In the case of the fire in the building from Drumul Taberei area, the decisional and informational flow, which includes the following systems: municipal disaster defence commission, military fire-fighters and the Inspectorate of the Military Fire-fighters Corp, functioned properly, corresponding with the actual technical facilities and endowment.

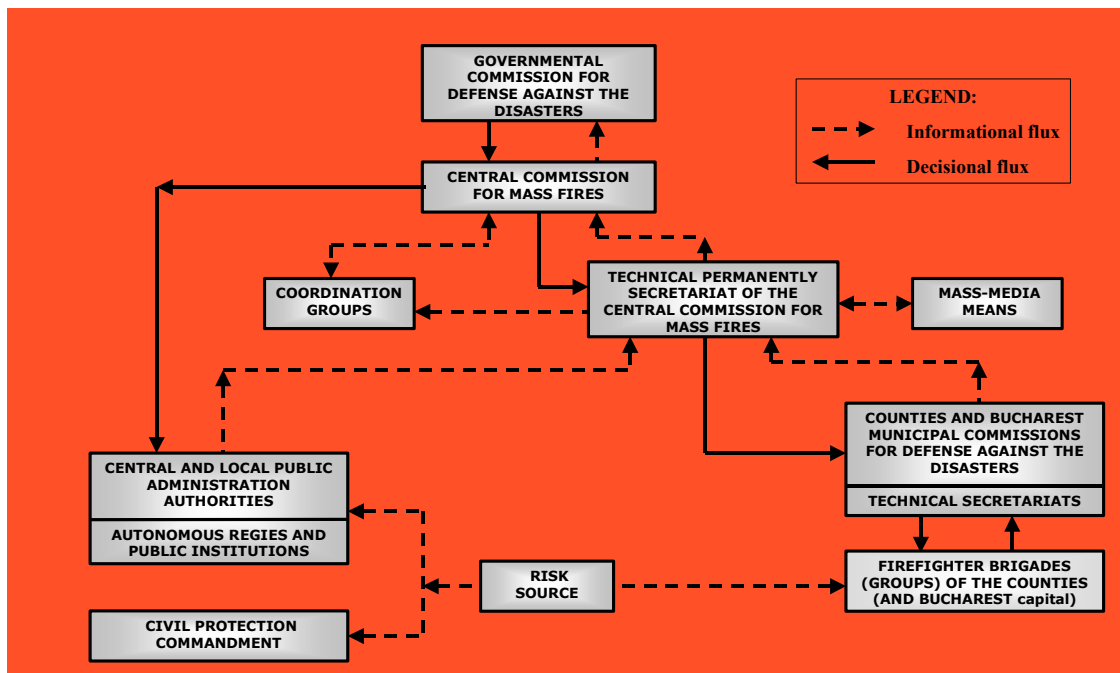


Figure 3. Scheme of the informational-decisional flux at the level of the central commission for mass fires

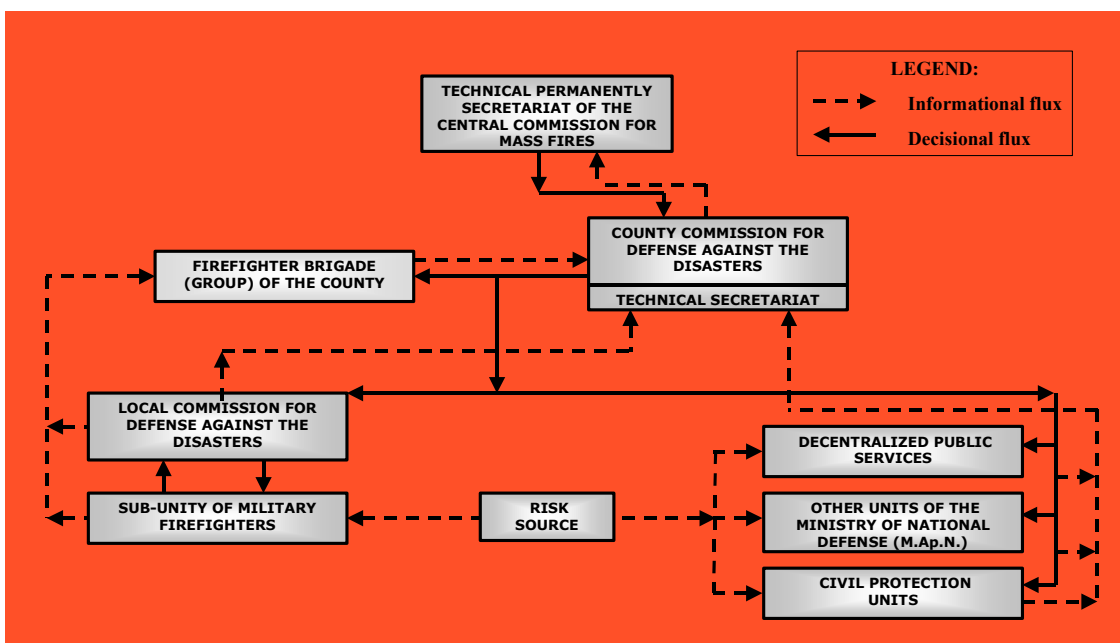


Figure 4. Scheme of the informational-decisional flux in the localities where function brigades, groups and subunits of the military firefighters

5.1 Lessons learnt

- The dissemination of information to the public regarding the causes of the fires in buildings could constitute an efficient method of reducing and preventing this type of disaster, saving lives and goods in the benefit of the whole community. In this spirit, in Romania is undertaken an intensified activity of education for preventing the fires in buildings, which includes the major segments of the population: scholars, teenagers, matures, elders including also the responsible factors of the entire socio-economic sectors of activity.

6. Socio-economic implications of the disaster

Due both to the protection measures against fire and to rapid intervention of the fire-fighters, in Romania only fires in buildings with limited extension were recorded.

Generally, the fires in buildings were produced due to the negligence of the population in handling the fire in houses, without accomplishing the norms for preventing and extinguishing the fires.

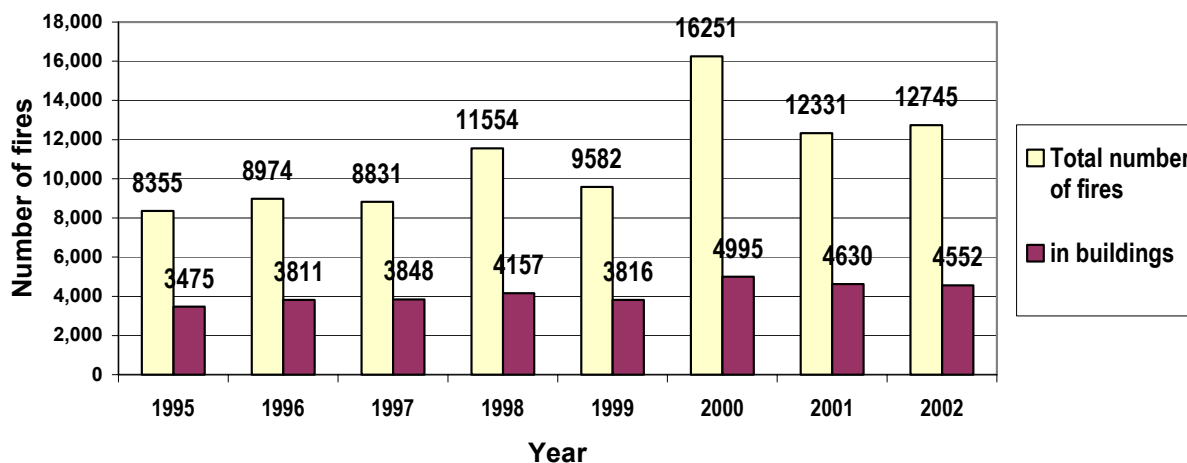
In order to reduce damages produced by fires in buildings, measures have to be taken at the level of the local public administration for intensifying the activities for fire prevention, by increasing the frequency of the controls in localities and the actions for information and preventive education of the population, using all the means and methods for mass media communication.

The fires evolution is determined by a series of factors which interact with the phenomenon, causing deviation of the tendency line. These factors are climatic, seasonal, economical and social. Most of 75% of the fires in buildings were produced due to not accomplishing the norms of prevention and extinguishing of the fires, the negligence and unknown way of using or maintaining the electrical devices, and also the large quantities of combustible materials existed in every home, which favour the fire propagation (see Fig. 5).



Figure 5. Large quantities of combustible materials are usually stored in the houses which favour the fire propagation (example in the affected 10-storey block from Drumul Taberei area)

Generally due to low income, the majority of the families did not afford to insure their house against disasters (including fire), and in case of a fire in a building there is no coverage for its damages, which frequently represent their entire fortune. Even this type of fire event represents a major component from the total number of fires recorded each year



(see Fig. 6).

Figure 6. Intervention of the military fire-fighters during 1995 - 2002 in fires in buildings

Acknowledgements

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Fire in apartment building at Karlstad, Sweden, in December 2001

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Karlstad Fire and Rescue Brigade, Sweden

1. The fire at Horsensgatan 88-96

On the night of the 4th of December 2001 a fire broke out on the 4th floor of a four-storey apartment building in Karlstad. One person died in the fire, which totally destroyed the entire 4th floor. 25 of the 93 apartments in the building were totally burnt out (Fig. 1).



Figure 1. View of the building after the fire

As the crews were getting close to the address they were notified through dispatch that there might be people still in the apartment concerned, and that it most likely was an apartment fire. As they turned the corner of the building, they saw a live fire with flames filling one apartment's windows (Fig. 2) on the top (4th) floor. The senior officer ordered a typical inside attack according to a SOP (standard operating procedure), with the intent of gaining access to the apartment and if possible save the person/s still inside.

The senior officer did not at this stage anticipate any special problems. He concluded in his size-up based on what he could see of the building, that they would have a good chance of extinguishing the apartment fire rapidly. He also expected the fire to spread upwards to the attic, and therefore called dispatch for more resources. He anticipated that the construction between the 4th floor and attic would be a concrete slab as was common practice with this type of building, and would therefore hold.

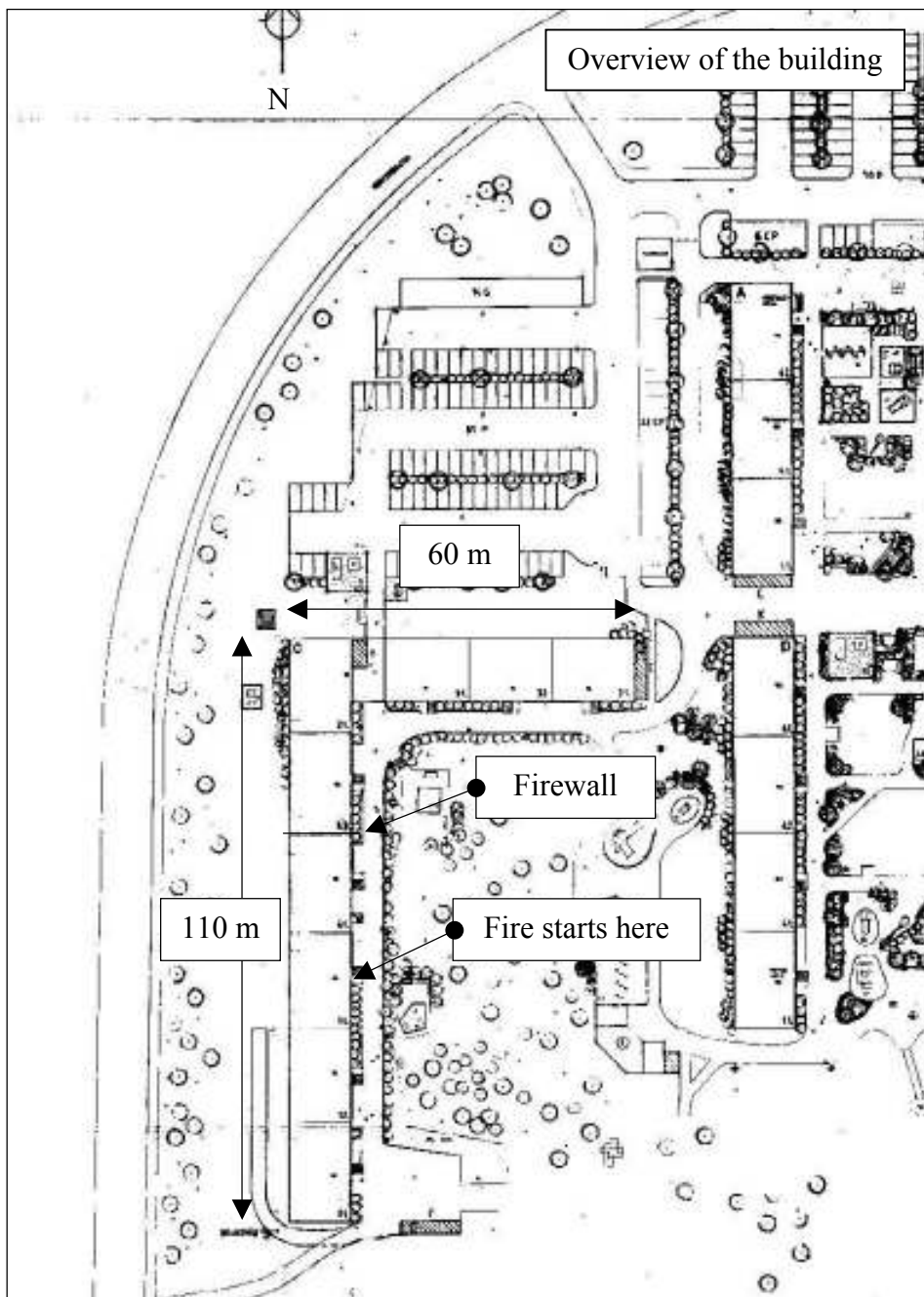


Figure 2. Outline of the building

During the initial inside attack, the senior officer suddenly saw from outside the house how the ceiling of the apartment suddenly caved into the apartment. He tried to reach the inside crew over radio, but got no response. As he already had put the remaining crews to work on and securing the water supply and getting onto the roof in order to ventilate the attic, he found himself alone and it took some 30 seconds to summon a fire-fighter to go in and investigate.

The crew had noticed the roof in the stairwell starting to sag, and had retreated to the 3rd floor just seconds before the collapse. Inside the apartment they had observed a body with such serious burns that the person was clearly deceased.

It was now clear that the fire had spread into the attic and that the occupants of the top floor were in danger. From this stage the spread of fire accelerated and the entire fire-fighting

effort was turned towards evacuating all occupants on the 3rd and 4th floor. The fire fighters had to run into the stairwells up to the 4th floor in each of the remaining eight staircases.

During the following 45 minutes the fire spread throughout the length of the entire attic, which was about 160 m long with a total area of about 1900 m² (see Fig. 3 and 4). In the same period of time, the fire spread to all 25 apartments on the 4th floor, totally burning them out. The attic had a firewall rated to withstand 60 minutes of fire (see Fig. 2). This was not known during the fire and none observed any delay in the fire spread that hinted of its existence



Figure 3. The building seen from SW, about 35 minutes after arrival. Fire started at the arrow



Figure 4. Fire spreads around the NW corner about 40 minutes after arrival

As the fire spread, the outer brick wall started to fail on the 4th floor. The housing complex is cut into an area of bedrock, which makes for a confined space of only 5 meters in width in front of it. Here, between the house and the rock wall of about 2,5 meters, all evacuees, fire fighters and vehicles had to go. Large portions of the outer wall crashed down into this space as well, and on a number of occasions the fire fighters had very narrow escapes (Fig. 5).



Figure 5. Brick wall falling in the space in front of the building (at the south end)

As an example one fire fighter sprained an ankle while jumping to the side. He went on to the 4th floor to investigate an unlocked door, where he banged on it and shouted, without any response. He opened the letterbox in the door and looked in. There was someone standing inside, as he could see a pair of naked feet.

He managed to get the person to open the door and she turned out to be a very large, disabled woman, who had not left the building for two years. He managed to talk her into walking down the stairs with him and just as they got to the 3rd floor, the ceiling of the staircase caved in on the 4th, narrowly missing them both.

It later turned out that the social authorities had placed a number of persons needed of different kinds of support or care in apartments on the 4th floor, since they were not disturbed so much by neighbours there.

It was decided at that time that all apartments should be searched and evacuated, due to the recurring collapses of the outside wall in front of the building. During the evacuation of more than 90 persons, the fire fighters had to constantly evade large portions of the roof and brick falling from the top floor (Fig. 6).

A large number of apartment doors had to be forced open as the occupants had locked them when they left. This took time and physical effort in the most critical phase of the evacuation. As soon as the reinforcements arrived they were tasked with a staircase to check and evacuate. By the time the entire building was deemed evacuated and empty, the entire 4th floor was ablaze and it was unclear if there were any more casualties in the 4th floor apartments.



Figure 6. The space in front of the building (note fire-hose under debris)

Due mostly to good fortune there were no serious injuries among the rescue personnel, and apart from the deceased occupant in the apartment where the fire started only a few occupants suffered from slight smoke inhalation and needed medical attention. The body of the deceased was found in the debris the next day.

The evacuees were assembled and taken by bus to a nearby hotel, where the police made lists of names, checking against lists of the occupants listed on the address. As some of the occupants immediately went on to relatives or friends before they were registered by the police it took about two days until all the occupants were tracked down.

An investigation into the cause of the fire was made by the police forensics department. The investigation stated that due to the severe damage to the apartment, a cause could not be concluded, and that the place of origin may have been in an area of the living room where the remains of a TV set were found.

The deceased had a medical history of mental care, and had spent a large portion of his life in institutionalized care. He was now renting his own apartment and was legally an ordinary person, with the right to rule his own life.

He was a heavy smoker and the social workers who had daily contact with him had many experiences of him throwing away cigarette butts in the apartment without extinguishing them. They had also noted numerous burn marks on his clothes, on the floor and on the furniture of the apartment. The social authorities, however, have no legal way to deal with persons that seem to be prone to cause fires. Even if they do not fully understand the danger by themselves, they cannot be forced to act in a safer way, as there is no legal way to do this. The society cannot prevent them from starting and possibly dying in fires in their homes.

Although there really is no way to conclude the real cause of the fire, it is likely that it was a “normal” chain of events. Whether it was a forgotten or dropped cigarette or a TV set that caught fire is not relevant to the chain of events that led to the unexpected speed with which the fire spread.

The building block was originally built in the early 1960’s and was then erected with three stories. All load-bearing components were made out of reinforced concrete slabs. In the late

1980's there was a shortage on small one-bedroom apartments, and an extra floor was built on top of the 3rd floor concrete roof.

The older part of the house did not have excess load-bearing capacity enough to allow for the 4th floor to be designed in the same way as the three others. It was therefore decided that the 4th floor should have a lighter construction with steel pillars and glulam beams (laminated timber) carrying a traditional wooden truss roof (see Fig. 7).

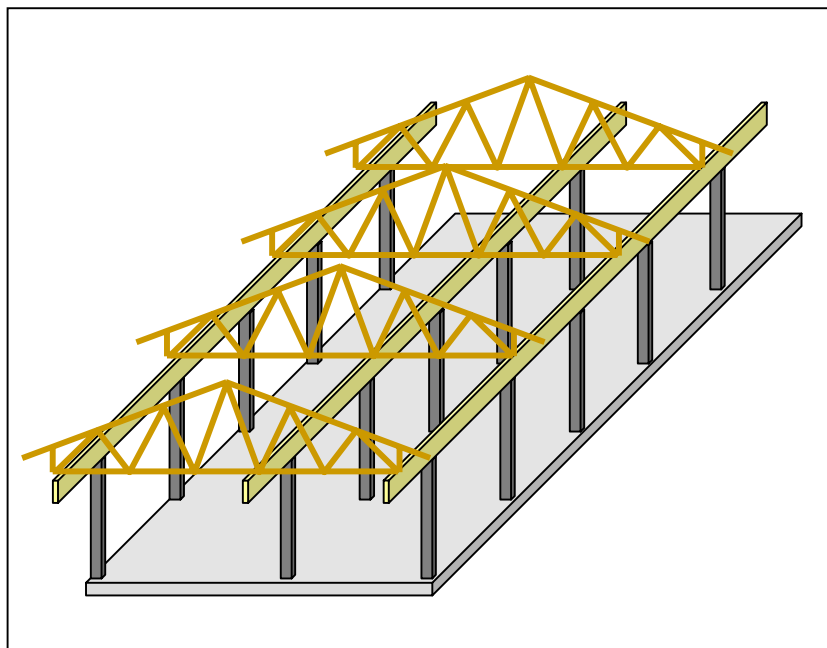


Figure 7. The 4th floor construction of steel pillars, glulam beams and wooden trusses

The intent of the building code has for at least the last 40 years been to contain a fire within the burning apartment for at least 60 minutes. Therefore all surrounding constructions must have the ability to withstand a fire for this period of time.

An exception is made when it comes to windows for practical reasons. It would be impossible to have non-opening windows, and it would be far too expensive to use fire rated windows in all apartments. Restrictions are instead made when it comes to the use of combustible materials on the façade.

The ceiling between the 4th floor and the attic was made up from two sheets of 13 mm drywall and some 400 mm of insulation, a construction that is tested and rated to withstand 30 minutes of fire.

The idea behind choosing a lower rating than the 60 minutes stated by the code was that a fire would need 30 minutes to get into the attic, and then another 30 minutes to get down into the next. The weakness of this solution is that it takes 30 minutes for the fire to reach the attic, and then about 30 more minutes to reach all the other apartments.

There is nothing new about fires spreading to the roof of a building as the windows break and the apartment is consumed by a flash-over. The flames reach many metres from the window and will ignite any combustible materials overhead.

The fire spread to the attic was much faster than the 30 minutes indicated above. Since the attic is unheated it has ventilation openings (see Fig. 8) between the brick wall and the roof.

This way the attic was ventilated through convection, with air coming in at the edges, and going out through vents just under the top of the roof.

The rapid spread of fire inside the attic was due to the use of a light wooden truss roof construction that did not meet the intended standards set in the building code.

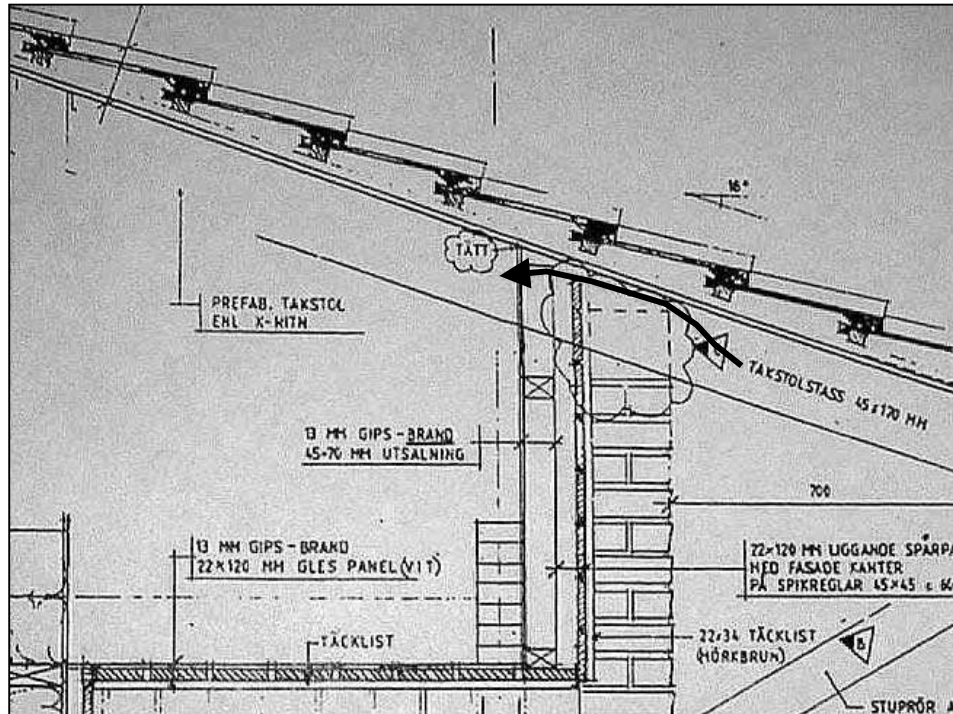


Figure 8. The construction where the wall meets the roof, opening at arrow

All fire-rated parts of the 4th floor construction was either anchored in or held up by the unprotected and unrated truss-roof (Fig. 9). As the trusses burned through and collapsed, the fire rated constructions failed in rapid succession. When they fell into the apartments they also damaged the apartment walls, allowing for horizontal fire spread (Fig. 10a-c).



Figure 9. The inside of the attic (neighbouring house) with trusses and insulation

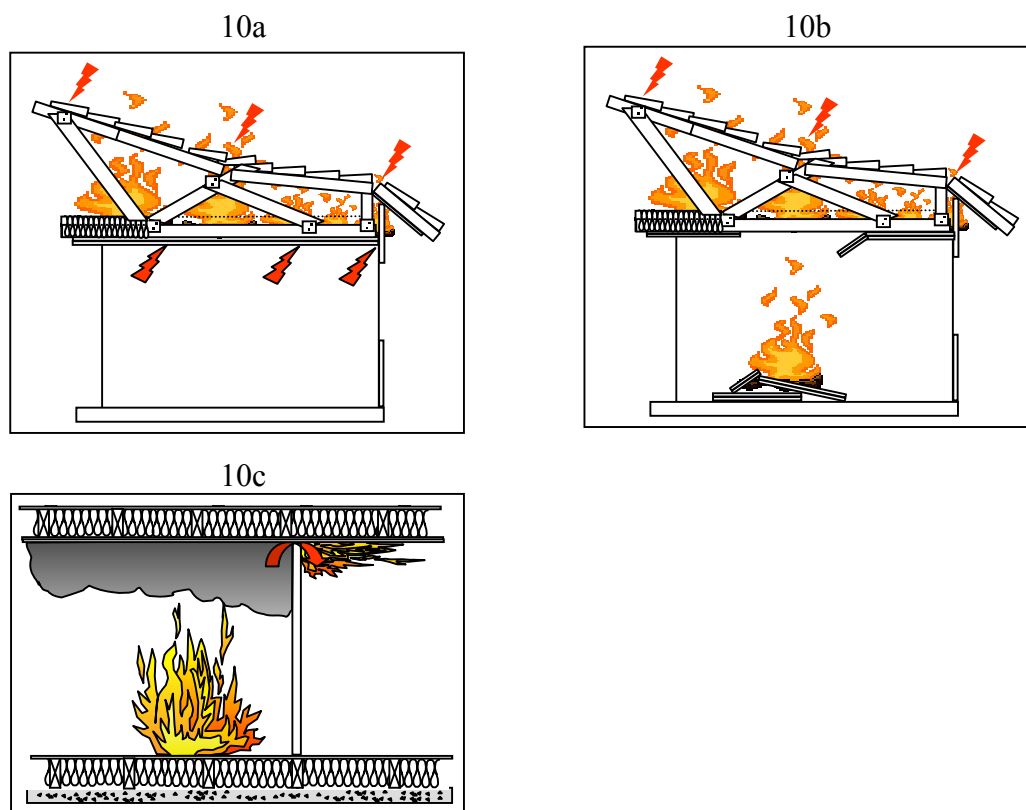


Figure 10. Fire spread through different weaknesses in the construction

Some of the construction solutions used in this house were partly common practice in 1991, but many of them are not to be found in the applicable building code.

2. Lessons learnt

- There is a lot to be won on investigating “ordinary” fires. That is where most of the fire fatalities and injuries occur.
- Fire investigations are an invaluable tool when it comes to connecting the people working with fire prevention with the people on operational duty. They give clues to what will happen in future fires and why, as well as what is to be done to avoid this scenario.
- The lessons learnt from a fire investigation of this type can have repercussions in a whole region or an entire country. Sharing the information on a case means that other municipalities do not have to wait for a fire of their own to learn the hard lesson from.
- Investigations can give guidance towards solutions. In this case it meant that the municipal housing company has installed residential sprinklers in all the other houses with this construction, since the investigation showed that there were no working alternatives. The company also started a project to evaluate and raise the level of the fire protection measures in its buildings.
- The weaknesses in this construction as well as in the building code were a result of a general lack of overall perspective. Although the different solutions and parts may

seem to meet the code one by one, this does not necessarily mean that the entire construction will perform as intended in the code.

- This fire points clearly towards the need for fire protection competence and widespread understanding of the impact of fire on a specific construction at all levels of the building community.
- Unorthodox construction solutions pose a very real threat to occupants or fire services personnel if they are not thoroughly tested and verified.
- The fire departments must take into account the possibilities of unorthodox constructions solutions during size-up.
- The building codes intentions must be followed in such a way that the constructions actually exceed the codes demands in real life, when put to the ultimate test - the fire.
- There is no way for the society to protect people whose behaviour make them a fire hazard, unless some kind of responsive system like residential sprinklers is installed. An alarm will alert the fire services, but the person will most likely be killed or seriously harmed by the fire anyway, as the fire grows to a life threatening environment long before help can arrive.
- Newspaper photographers with digital cameras can provide detailed information on the rate of spread in a fire, as each photograph also has registered in it the exact time it was taken.

3. The national investigation program

Around 30 brigades, with 40 trained fire officers, have been seconded to the SRSA's (Swedish Rescue Services Agency) national fire investigation programme. Every year around 500 investigations are performed.

The programme complements the decreasing number of police reports. The police only investigate if a crime has been committed or is suspected. The collation and analysis of the details of fires is conducted in order to increase knowledge about fires. Particular emphasis is placed on investigating the development of fires, surveying, analysing, and suggesting measures to be taken as regards fatal fires, hearth fires, and certain other types of fires. The programme provides better knowledge about fires and their causes, and highlights dangerous or defective products. The results are made public and product manufacturers and other stakeholders are informed. Another positive effect is the presence of fewer "unknown" causes in the general fire reports. The SRSA can also react to new fire risks using the network of fire officers on the fire investigation programme.

The annual cost for the program is around € 300,000. The program and the costs are justified by the national advantage of the results since some problems need to be handled on national or even international levels. Single brigades cannot find or identify fire problems from single products and the cooperation between its members and the SRSA has resulted in safer products.

A proposed new legislation will entail a mandatory basic investigation after all fires, and other accidents attended by the fire brigade. The idea is to use, beside other experts, the experience from rescue workers such as fire officers.

Fires' Control System In Lithuania

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1. Overview

On average, 15,000 fires break out every year in Lithuania, 40% of those in dwelling houses and public buildings (Fig. 1). On average more than 200 persons, 14 children among them, perish in fires every year. Fire losses arise to 1.7 million Litass (equivalent to € 490,000) of public property and 21 million Litass (equivalent to € 6 million) of private property. Main causes of fires are the following: negligent behaviour with fire (66%), inappropriate usage of electric installations (10%), inappropriate usage of heaters (8%), arsons (4%), technological infractions (1%), other or unidentified causes (11%).

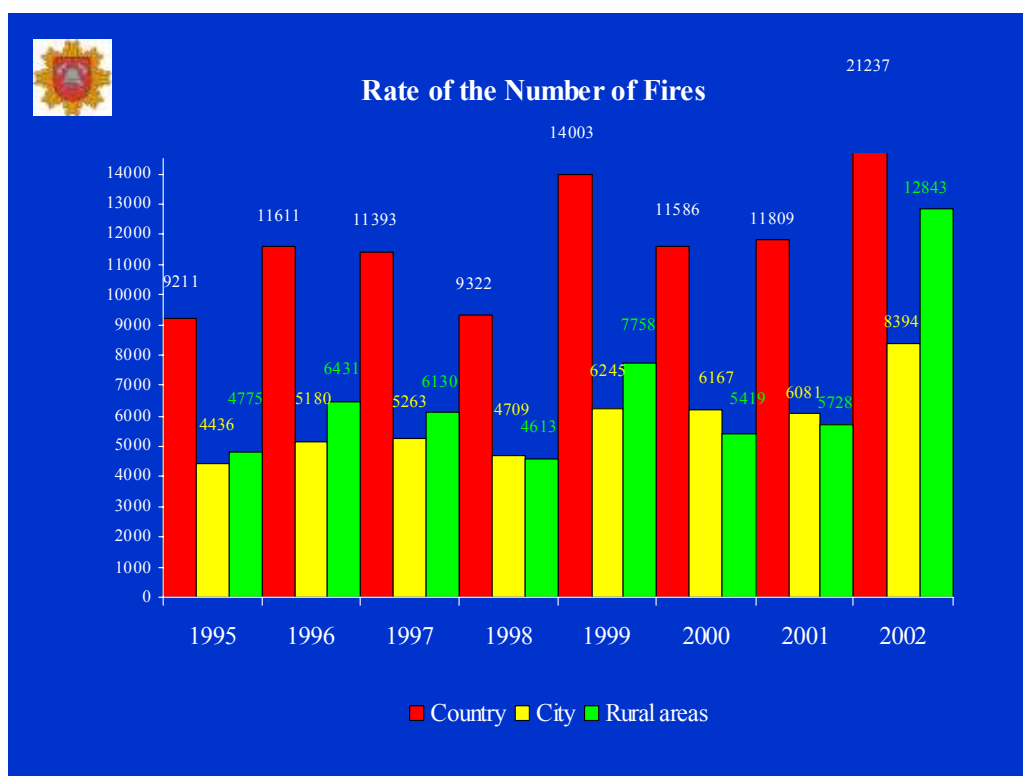


Figure 1. Rate of number of fires in Lithuania

The average rate in the country is 413.33 fires per 100,000 inhabitants, in rural areas the number of fires reaches 689, which is twice the EU countries' average. Such bad current situation is due to specific and almost stable economic problems in rural areas: late alarms because of telecommunications network lack, bad roads, unemployment, unkept stoves and chimneys and noncompliance of prevention program in residential sector.

Approximately 260 people are rescued in fires every year.

In 2002 the number of active fire fighters in the country was one of the smallest per 100,000 inhabitants across Europe (according to CTIF statistics). This number is smaller than in well economically developed countries as Belgium, Netherlands and Denmark, where the smaller

number countervails with the new modern equipment and advanced road and fire water supply infrastructure (Fig. 2).

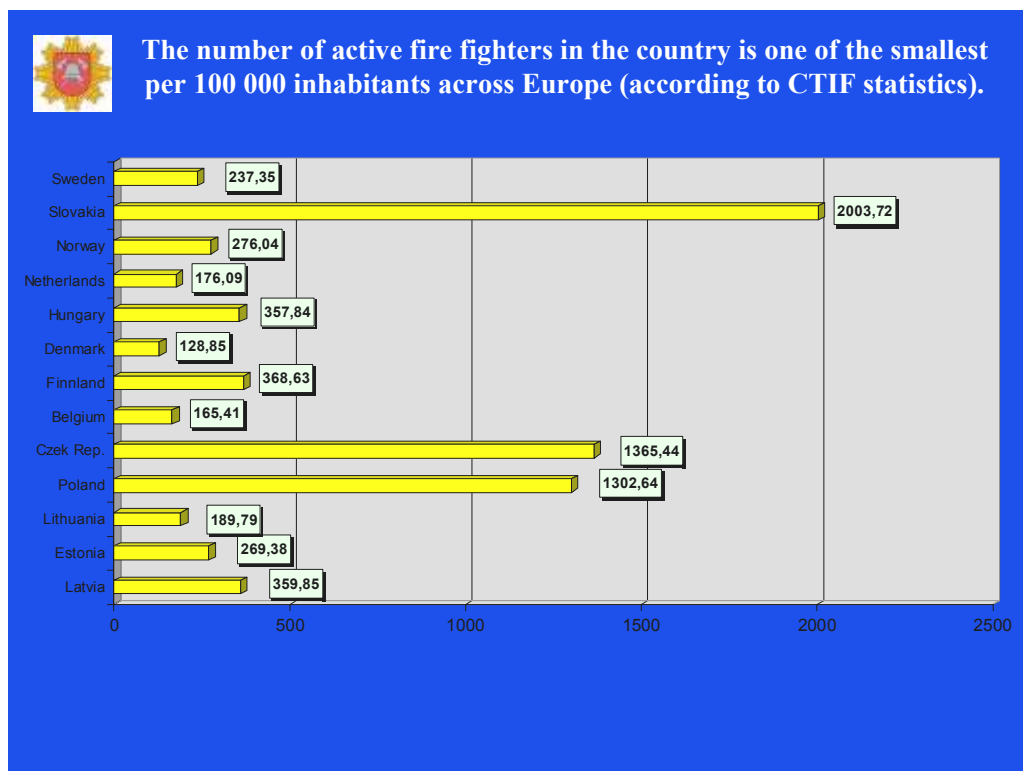


Figure 2. Number of fire fighters per 100,000 inhabitants in various European countries in 2002

2. Preventive measures

In order to ensure fire prevention, enterprises, institutions and organizations have to keep to the following requirements:

- To envisage solutions, which could ensure people safety and property evacuation in case of fire.
- Action plans in case of fire are to be worked out in enterprises, institutions and organizations, where more than 100 people stay permanently.
- Risk management groups in charge of fire safety condition in the building are to be formed in industrial buildings where more than 50 persons work permanently.
- Conforming to criteria approved by the Government, high fire risk industrial buildings have to be provided with the local fire brigades.

The control of the fire safety condition in buildings is carried out by accomplishing technical inspections:

- Special purposes buildings: the national radio and television central offices, hotels, theatres, cinemas, concert halls, prisons, hospitals, sanatoriums, rehabilitation centres, nursing homes with more than 50 beds for in-patients, have to be controlled twice a year.
- Cultural heritage and public purposes buildings, churches, medical institutions (when beds' number is up to 50 places) schools, kindergartens, museums, bus and railway stations, banks, post-offices and courts are inspected once a year.

During fire safety inspection in weekly kindergartens, children and babies' homes, hospitals and nursing homes, inspectors check the capability of staff to act in case of fire by night, inspect exit ways and condition of fire equipment. Such inspections are carried out every six months at least.

Besides ordinary inspections, such buildings are inspected without warning at any time of the year taking into consideration large-scale fires in foreign countries (e.g. Ostankino TV tower in Moscow, mass fires at children's care institutions in Russia).

3. Structure of fire and rescue forces

The fire rescue service is divided in two levels at municipalities in Lithuania: state fire and rescue brigade and municipal fire and rescue brigade.

The State Fire and Rescue Service consists of the Fire and Rescue Department, 55 fire and rescue services located in principal cities of municipalities, the Firefighters Training School and the Fire Research Centre, what currently makes around 5,000 active officers. On the other hand, the staff of the remaining 275 municipal fire brigades arise to 2,100. On average, each municipality has 5-6 fire brigades, state fire and rescue brigades excluded. Biggest cities have only state fire and rescue brigades.

The Law on Fire Prevention regulates functional procedures and principles of the fire control, determines responsibilities and main tasks of fire and rescue services.

Across the country fire fighting is organized at municipal, county and state levels. If fire and rescue forces designated for fire fighting according to the emergencies elimination plan are deemed as insufficient to eliminate fire, the state fire and rescue brigade located in the central city of the municipality endorses the responsibility of accident management and call on supplementary fire and rescue forces. The chief of the central county fire and rescue service is responsible for carrying out fire prevention and suppression measures at the county level, same as the Director of the Fire and Rescue Department is responsible at the state level. The currently established overall fire and rescue forces management system, functioning according to the republican emergencies management plan, allows to manage effectively fire and rescue forces at any location of accident. Therefore in case of accident there is a possibility to send supplementary fire and rescue forces not only from the same municipality, but from any other county and even from the whole country. This system allows firefighters to fight effectively fire effects in despite of territorial borders.

The chief of the fire and rescue service is in charge of emergency preparedness within the territory of municipality. He jointly with the chief of the municipality fire and rescue service, who is subordinated to the mayor, organizes preparedness. Their tasks and duties are the following:

- To implement fire prevention measures.
- To prepare emergency elimination plan, in which fire and rescue services dislocation and distribution in the territory of the municipality and in special buildings should be drawn.
- To establish or liquidate fire and rescue brigades, to determine goals and functions of the service as well as response area and to ensure technical provision.
- To organize and implement vocational training.
- To provide with standards for the fire and rescue equipment.

- To create databases (of streets, squares, fire water suppliers, dangerous buildings filled up with hazard materials, lists of those materials and their specifications) for use of communication centres.
- To work out special emergency management plans for dangerous buildings (such plans are made for all high importance buildings (the state, governmental or municipal institutions, public buildings, health and educational buildings; industrial buildings with chemical, fire or explosion risks and commercial or storage buildings).
- To control fire water supply systems.
- To collect and to analyse statistics, to organize discussions on lessons learnt from the large-scale fires abroad.
- To ensure functioning of communication means.

The plan of fire and rescue forces saturation is based on following principles:

- System of fire and rescue forces and equipment dislocation in view of administration units and living areas.
- Analysis of risks: classification of buildings according to the risk criteria and possible effects of accidents for human health and environment depending on hazard materials involved.
- Planning of emergency response scale taking into account all criteria which influence extent of accidents.
- Interdepartmental cooperation.
- The most efficient usage of resources.
- The general republican plan of forces saturation.

The fire and rescue forces sent to the accident place have a conventional code: "Dispatched Forces Number" (DFN), which conforms to the number of fire trucks sent to the response place. In Lithuania 5 DFN are used:

- 1 DFN – 2-3 main fire truck (FT)
- 2 DFN – 4-5 FT
- 3 DFN – 6-7 FT
- 4 DFN – 8-9 FT
- 5 DFN – 10 and more FT

In specific cases the chief of the fire and rescue service referring to the principles listed above defines the DFN and decides what sort of other specialized forces is required.

4. Fire control

The chief of rescue operations leads a fire extinguishing operation. He leads rescue operation respecting the following priorities:

- To save human life and rescue – in case of fire the fire and rescue forces must primarily rescue human life.
- To ensure safety of a firefighter – the rescue operations leader is supposed to lead operation taking into account safety and health conditions of staff subordinated to him

operating in the red zone. Property preservation risk should not exceed the life risk of rescue personal.

- “The minimal spread of fire” – the rescue operations leader should endeavor to extinguish such fire as it was at the arrival of first responders.
- To presume the worst case – the rescue operations leader should evaluate risks dynamics, to preview the worst change of the situation and in respect of that to concentrate rescue forces.
- “Effective response” – fire and rescue forces are supposed to organize their operation in such way that they could be able as soon as possible to provide the help and to break down the fire.
- “Qualified help and qualified leadership” – only persons with appropriate qualification are allowed to rescue and to lead rescue operations.
- “Interactions” – the efficiency of rescue operations depends on cooperation with state, municipal and non-governmental institutions and inhabitants.
- “The minimal damage” – the fire and rescue forces have to strive not to increase the damage caused by fire.

In case of fire, the fire operations leader commands all rescue forces. He must:

- collect all available information about the building where the fire has been broken;
- evaluate the situation, to organize the exploration of the fire focus; to identify fire operations tendency; to cancel or upgrade “dispatched forces number”;
- distribute tasks;
- identify emergency zones: hot (“red”) zone; warm (“yellow”) limited access zone, cold or support zone; a zone where fire and rescue forces should be located, a place for headquarters, a place for injured persons collection if necessary and a place for victims collection;
- determine fire elimination ways, means and scope of operations;
- determine communication order on the scene of accident as well as interaction with other forces;
- inform about fire localization, elimination and final works stages;
- ensure the staff safety and health control.

5. Large-scale fires in Lithuania

Cases where officers of the Lithuanian Fire and Rescue Department have been acting as operation leaders will only be mentioned as follows:

On 2 August 2002, in Trakai region the fire broke out within the territory of the company EGAPRIS. Over 7,000 tones of old tires and rubber waste were stored on the ground. 32 fire trucks, 180 firefighters and 16 special purposes vehicles were involved in the response operation. Used tires and rubber waste stored in stockpiles burnt away (176 m x 113 m); the total surface of the stockpiles preserved was 8,850 m² (118 m x 75 m).

On 3 October 2002, in Panevėžys the fire broke out in factory EKTRANAS (3-storey ferro-concrete industrial building), in the kinescopes’ production line. Rescue forces involved 21

fire trucks, 85 firefighters, 80 soldiers and guard staff. 15,000 m² of roof construction burnt away and a part of metal roof constructions collapsed in the 2nd floor. 1 worker of the factory was intoxicated by gas. 28 workers of the factory were evacuated by using extension ladder truck.

On 27 August 2002, 101 water tanks, 346 firefighters and officers, 30 military officers and 164 persons from other institutions were involved in 43 peat fires across the country. The total surface of the peat fires ground was 410 ha. Approximately 20 ha of fires were extinguished a day. The republican headquarters was leading forces at the Fire and Rescue Department.

The 16 July 2003 explosion in Ukmergė, in the stock company UKMERGĖS GELŽBETONIS' styrofoam shopfloor. The styrofoam shopfloor collapsed. 50 m² of the building rubble was involved in fire. 4 injured workers were rescued under the ruins. The total number of injured people: 10; 3 casualties. Forces involved: 12 water tanks, 1 fire truck and crane.

6. Lessons learnt and conclusions

6.1 Lessons learnt concerning fire prevention measures

- After the fire on the tires' storage ground, the Fire and Rescue Department approved the temporary fire safety regulations for open storages of tires and rubber waste. After having applied these regulations in other open storages the big fire was avoided and the broken fire was eliminated with much smaller efforts.
- Severe fires in housing sectors pushed fire officers to organize special campaigns every year. During those campaigns fire and police officers as well as municipal social workers visit living places of asocial families, explain how to avoid fires, how to behave in case of fire and distribute information leaflets.

6.2 Lessons learnt concerning fire preparedness measures

- In developed emergency action plans (EAP), it is necessary to indicate potential risk places, storages of hazard materials and gathering places of people as well as to highlight buildings with people present at night.
- To preview rescue alternatives in EAP in high raised buildings, without mobile rescue equipment. The rescue equipment available in Lithuania provides with rescue operations only in buildings up to 8 floors.
- To preview possibilities and to make contracts allowing to use special equipment (bulldozers, diggers, trucks, tractors, etc.) in fire fighting.
- To preview communication possibilities when rescue forces arrive from different counties.
- To collect information in databases about construction solutions of each building.

6.3 Lessons learnt concerning fire response measures

- It is essential to harmonize fire extinguishing equipment (hoses and couplings) standards in the whole country (as some fire brigades use different equipment received as technical support from Sweden, Denmark and Germany).

- For communication, in case of large-scale fires to use emergency channel, available in radios of all fire and rescue services, police and ambulances; this channel is designated for overall rescue operations coordination.
- In order to ensure non-stop water supply when the water supply hose is long enough (1 km and longer), it is recommended to reserve 1 additional hose for every 200 metres of the line, to put next to the line, as well as to have in proximity the hoses' truck for hoses exchange;
- In case of large-scale fires it is necessary to arrange points for equipment maintenance and repair, a provision point for smoke divers, meals and resort places.

6.4 Lessons learnt related to public information

- An expeditious spreading of information through mass media in case of over concentration of smoke in the air and about security measures in living areas is imperative (in case of peat fire the air was contaminated in big cities).
- Only one officer should be information supplier.

7. Proposals

Efficient provision of rescue activities (fire elimination included) in the shortest time is possible only when fire brigades' locations are distributed in the most appropriate way within the territory of the whole country. It is suggested that it would be rational to determine the response time in case of any rescue operation according to parameters concerted, or to provide countries with recommendations in defining different response time standards on their own.

It would be desirable to create a website providing with the standard form of fire operation description. Such information could be provided by fire brigades from European countries with a purpose to exchange information and experience among European fire and rescue services.

Recap of lessons learnt

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Main lessons learnt from the management of the fires portrayed earlier in this report have been classified in this chapter according to major phases of disaster management, including (1) prevention, protection and safety measures, (2) preparedness plans and actions, (3) intervention and (4) dissemination of information to the public. Additional lessons learnt and recommendations drawn at the workshop debate have also been integrated in the relevant sections.

It must be noted, however, that this separation into phases does not imply a strict boundary between them. In fact, the whole system has many interlinks. Thus, some of the lessons learnt included in a particular major phase of fire management below can also be applicable in other phase.

1. Lessons learnt concerning prevention, protection and safety measures

Appropriate legislation is the main factor for prevention of and protection from fires in buildings. Legislation includes in the first place building regulations and codes including fire safety considerations (e.g. passive fire protection such as fire-resistant construction and decoration materials, compartmentation, etc., and active fire protection such as automatic fire detection and alarm systems, sprinklers, portable fire extinguishers or fire hoses, emergency lighting, etc.).

Specific lessons learnt can be considered as follows:

- Building regulations and codes must be appropriate and specific for the type of occupancy (e.g. residential buildings, hotels, hospitals, department stores, cinemas and theatres, discotheques, restaurants, office buildings, factories, etc.), as well as for the size, the building components and their testing, inspections, etc.
- Legislation on fire prevention and safety should be applied to all existing buildings not just to new or renovated buildings. Fires in old buildings, which have often been rebuilt and altered (often because of occupancy and occupants change), create many problems in prevention (as well as in response). Old buildings are seldom upgraded in fire safety aspects.
- Legislation should be reviewed and updated on a regular basis, not just after a big fire.
- Legislation on fire prevention should be linked to other legislation to avoid conflict.
- It would be desirable to establish a set of basic fire safety regulations that are common across EU countries.
- Construction materials (generally after about 1960) contain much plastic, which creates special problems with heavy smoke production and fast spread of fire. This has seldom been taken into account in fire safety risk analysis.
- In public premises floorings and furnishing must be of low combustibility and may not produce toxic gases.
- It is very important to set up and maintain a systematic process of operational risk assessment including mainly collection of information, generic hazard analysis, site specific hazard analysis, site specific assessment, scenario type and dynamic risk

assessment. This process should also include additional steps which belong to other phases of fire management, especially to preparedness actions.

- The collaboration of fire safety officers, operations planning and owners of premises and buildings, where similar conditions may exist should be encouraged beyond fire certification or licensing of individual properties.
- Regular and rigorous inspections of buildings are necessary. The responsibility of the owners of buildings or premises to comply with fire safety regulations must be made clear during inspections.
- A second means of escape at a reasonable reach of any point is shown to be imperative, especially in public premises.
- The design of means of escape and of other fire safety measures should be based on assessment of the risk to the occupants. In residential premises designed to be used by persons with disabilities or restricted mobility (e.g. hospitals, homes for the elderly and sheltered housing) additional fire precautions are required, especially when staffing does not correspond with what is necessary to provide assisted escape.
- Requirements for ventilation need to be adjusted for health care buildings in order to limit rapid spread of smoke.
- Proper compartmentation methods are efficient to prevent or slow down fire and smoke spread. Lack of compartmentation in escalators, staircases and lift shafts has been a major reason for the catastrophic consequences of some fires in department stores.
- Properly installed sprinkler systems, covering the whole building, have proved to prevent fires from spreading. They also often extinguish the fire. Sprinkler systems can be very useful in large public premises such as department stores. In particular, densely built old wooden houses should be protected from fire by using these systems.
- Many catastrophic fires where there was no alarm system have revealed that although its availability would have alerted the fire brigade earlier, only a sprinkler system covering the entire building could have prevented the casualties.

2. Lessons learnt concerning preparedness plans and actions

Preparedness mainly includes such aspects as specific emergency plans, organisation of intervention services and teams, training of emergency services, owners and staff of premises, etc. Main lessons learnt are as follows:

- In cities it is necessary to have a powerful fire brigade with appropriate means and equipment for fire fighting and rescue, trained personnel, and fire stations well distributed over the extent of the city. Fire fighting means and equipment should also be kept up-to-date.
- Constant training of fire fighters in fire fighting and rescue/evacuation of people using ladders and turntable ladders or inside the building using breathing apparatus and smoke hoods for the persons is imperative. These exercises also enable to verify rescue and emergency plans.
- Pre-planning for fire fighting must consist of knowledge from both the fire prevention inspectors and the fire fighting staff. Successful fighting of fire can only be achieved through cooperation between prevention measures and traditional fire fighting knowledge.

- Fire safety management plays a very important role. In public premises there must be fire emergency plans, exercises and training of staff. In these premises fire safety should include risk analysis and emergency planning by the owner as well as assigning a person to be in charge of fire safety matters. This person should be responsible for the fire safety logbook, inspections, regular test of fire systems, maintenance, working out emergency procedures and training for the staff, including fire and evacuation exercises.
- Actions taken by staff of public premises in case of fire are very important. It is necessary that staff are trained and that they perform regular fire and evacuation drills. Staff handling security should also be trained on how to evacuate a large number of people. There is often room for improvement in this respect.
- Fire brigades need to improve their emergency plans and have regular drills with the staff of the premises.
- The local fire brigades must pay attention to exercises on how to fight fire in densely built wooden houses.

3. Lessons learnt concerning response/intervention actions

Response/intervention actions in the event of fire mainly concern emergency services (i.e. fire brigades, medical services, police, volunteers, etc.). Intervention of fire brigades plays a major role in response to fires. Such intervention includes the use of duly equipped fire fighters, command vehicle, pumping appliances, straight and turntable ladders, etc. Means used by other emergency services include mainly ambulances.

Main lessons learnt regarding response/intervention are as follows:

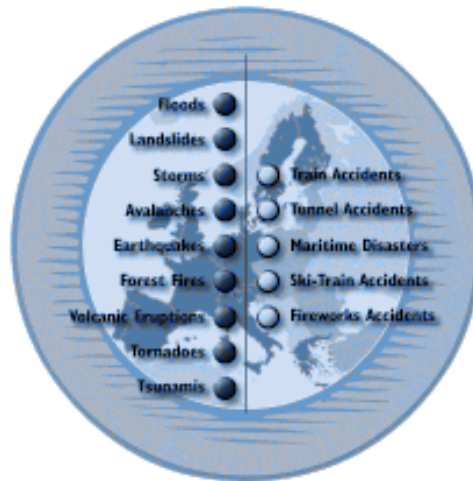
- In interventions in fires in buildings, evacuation/rescue of occupants is the first priority. Fire extinguishing comes next, although it is often carried out simultaneously.
- Timing of fire fighters intervention is always crucial.
- A powerful fire brigade, well trained and coordinated, with short intervention time, is imperative, especially in cities with old buildings. In some cases, lack of a national standard and legislation for fire fighting related equipment and material at the time of past fires prevented efficient fire suppression.
- To optimise the interventions of the fire brigade, each brigade is to draw up special intervention plans with regard to buildings that constitute a potential hazard.
- The delay in alerting the fire brigade has always great significance. Late alert has been shown to be responsible for major damage and casualties in many fires.
- The limited space or accessibility to fire sites for fire brigades, especially in city centres, can be a major constraint both for proper operation of fire appliances and for fire fighters intervention. Public works in the streets or roads leading to any premises of high risk should ensure access by fire brigades.
- Use of breathing apparatus by fire fighters in heavy smoke conditions should be a must.
- In rescue operations, the use of state-of-the-art ladders and turntable ladders, together breathing apparatus by fire fighters, is very important.
- Persons screaming loudly must not be most endangered. The leader of the intervention team has to decide who is rescued first.

- The rescue of unconscious persons is very difficult. Sometimes the effective way may not be the most gentle.
- Emergency plans, fire risk assessments, etc., are in most cases unrealistic when determining the time and means required to evacuate premises where there are persons with disabilities. Physical, mental or psychological impairments can significantly impede a person's ability to evacuate without help. Such impairments may also be of temporary nature such as persons with sedative medication.
- To reduce damage through fire fighting action, fire brigades should look over their standard tactics by given more consideration, when possible, to the likely high loss of property caused by their action (e.g. by excessive use of water, inducing smoke spreading to other building areas, etc.).
- Ways to ventilate smoke contaminated areas and rooms other than the most common one, which consists of directing the smoke through stairways and corridors, must be found, since these are the emergency routes and exits, and in most cases the only access for the fire brigade.
- Development of medical contingency plans for transport of injured persons is necessary. Liaison between fire services and medical authorities is thus essential.
- It is necessary to provide psychological support to the survivors, the bereaved and the intervention teams.
- Fire investigations are an invaluable tool when connecting people working on fire prevention with people on operational duty. They give clues to what will happen in future fires and why, as well as what is to be done to avoid this scenario.
- The lessons learnt from a particular fire investigation can have repercussions in a whole region, an entire country and even across country borders. Sharing the information on a case it is important so that other municipalities do not have to wait for their own fire to learn the hard lesson from. Sharing this information at EU level is also considered of high relevance.

4. Lessons learnt concerning dissemination of information to the public

Information to the public mainly regards their right behaviour not to cause fires and for protection and escape in case of fire. Some specific lessons learnt are as follows:

- People awareness of the danger of fire and smoke is very important. Information campaigns must address this issue.
- Rapid dissemination of information on recommended population behaviour through the media is essential in case of high concentration of smoke in the air.
- Appropriate fire hazard warning and safety signals in all public buildings and premises are necessary.
- Occupants and temporary users of some premises must be informed about the emergency procedures (alarm signal) and the right behaviour in case of fire and the means of escape. In hotels, a leaflet on the door of each room gives this information. It is also recommended to give additional verbal information to the guests.
- Information to hotel guests about alarm signal, the right behaviour in the case of fire and the means of escape in different languages is imperative.



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